

Delta II Explosion Plume Analysis at Cape Canaveral, FL: Evaluation of Meteorological and Dispersion Modeling System

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Engineering • Science • Technology

Delta II Explosion Plume Analysis Evaluation of Modeling System

- Delta II explosion background
- ERDAS meteorological and dispersion modeling system
- Delta II case study
 - Meteorological observations
 - Radar observations
 - RAMS model
 - HYPACT model
 - Observed vs. Predicted
- Ongoing RAMS evaluation in ERDAS

Delta II explosion background

- Delta II rocket exploded 12.5 sec after liftoff at Cape Canaveral AFS Launch Complex 17 at 1628 UTC, January 17, 1997
- Explosion produced two clouds which were tracked by radar and modeled with ERDAS

ERDAS meteorological and dispersion modeling system

- ERDAS (Eastern Range Dispersion Assessment System)
- RAMS (Regional Atmospheric Modeling System) provides meteorological forecast data for dispersion model(s)
- HYPACT (HYbrid Particle And Concentration Transport) model is primary dispersion model
- Other dispersion models and data available at CCAFS thru MARSS e.g. OB/DG, wind towers.

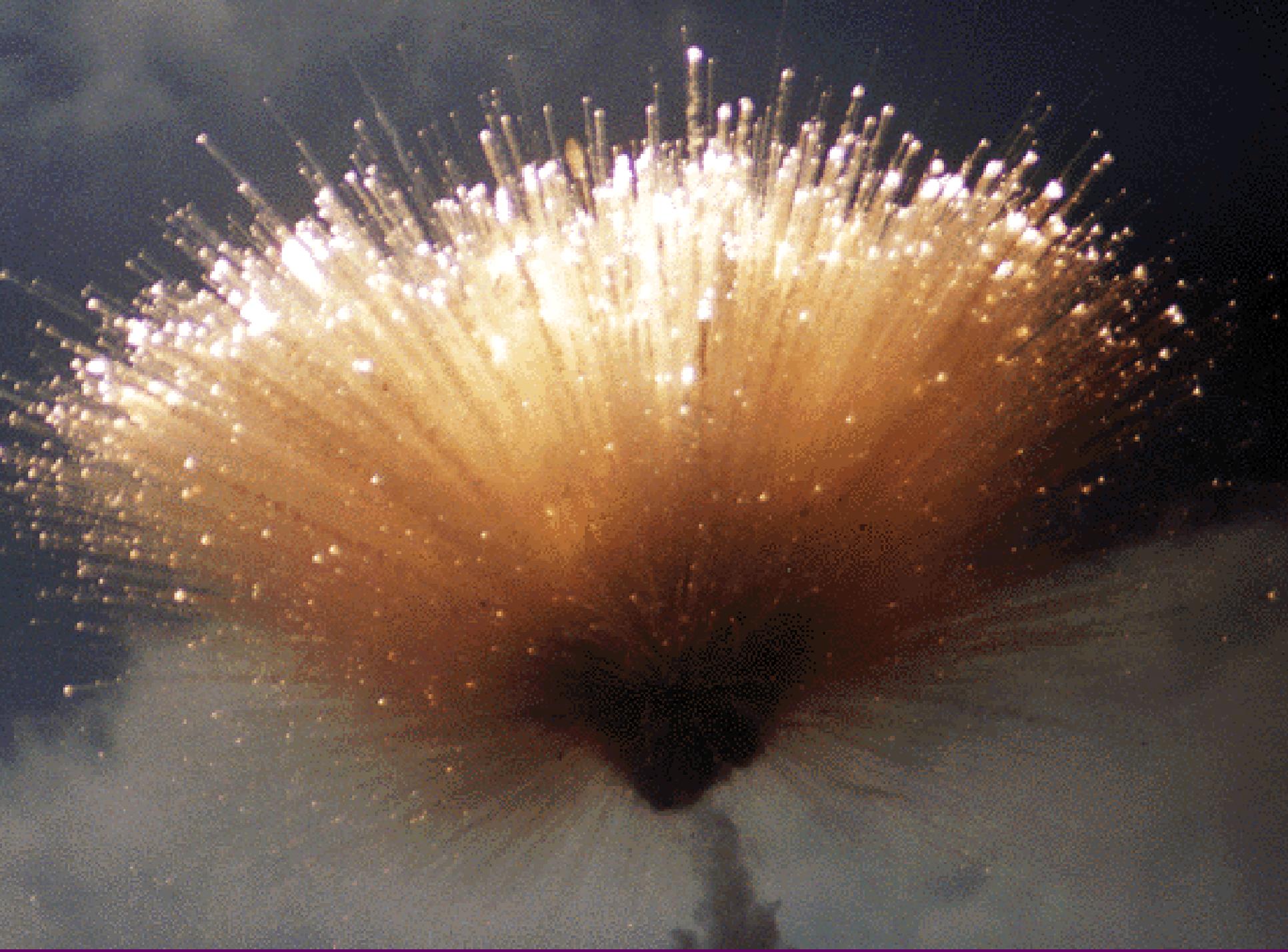
















STATION 06
Lat. 28 Deg. 26 Min. 48.784 Sec. N
Long. 80 Deg. 34 Min. 08.379 Sec W
Roll 1, Frame 6 (PL97C-10151.06)















17 Jan 1997
16:29:22 UTC

← Plume 2

← Plume 1







JAN. 17 1997

5 NEWS



**DOPPLER
9000**
RADAR NETWORK

Sharpes

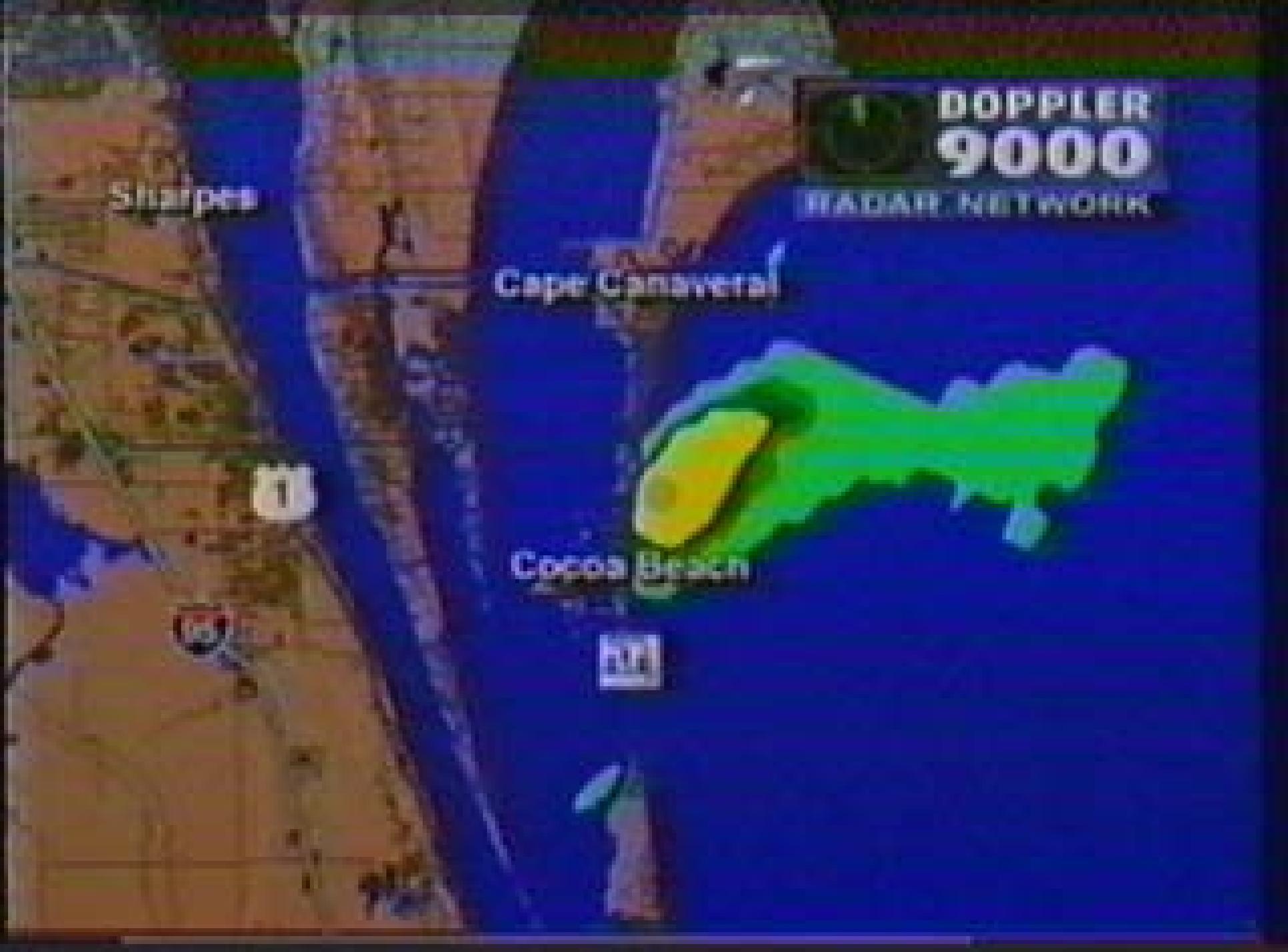
Cape Canaveral

Cocoa Beach

1

100





Sharpea

Cape Canaveral

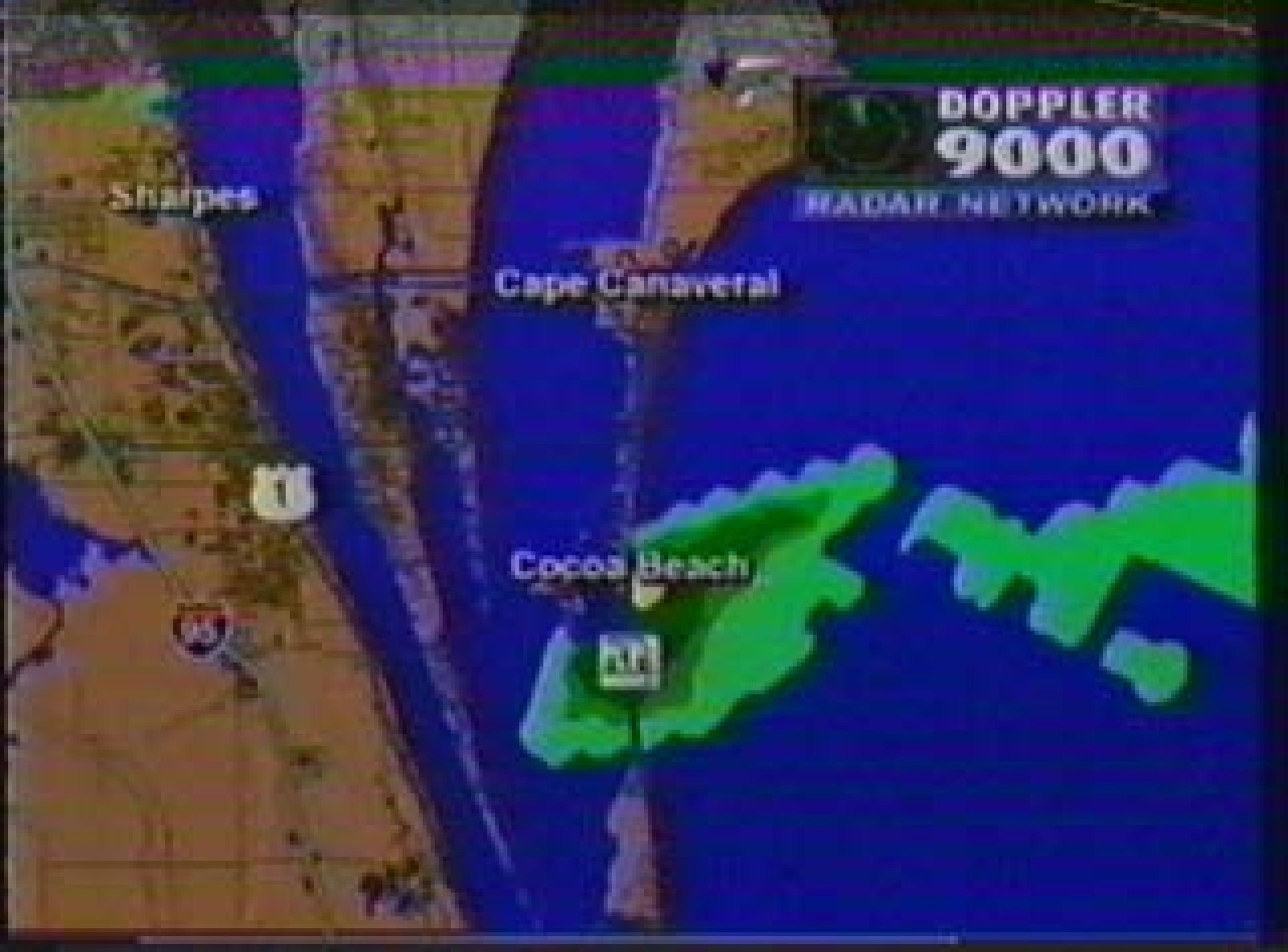
Cocoa Beach

DOPPLER
9000
RADAR NETWORK

1

55

RT



Sharpes

Cape Canaveral

Cocoa Beach

 **DOPPLER**
9000
RADAR NETWORK

1

35

RF

**DOPPLER
9000**

RADAR NETWORK

Sharpes

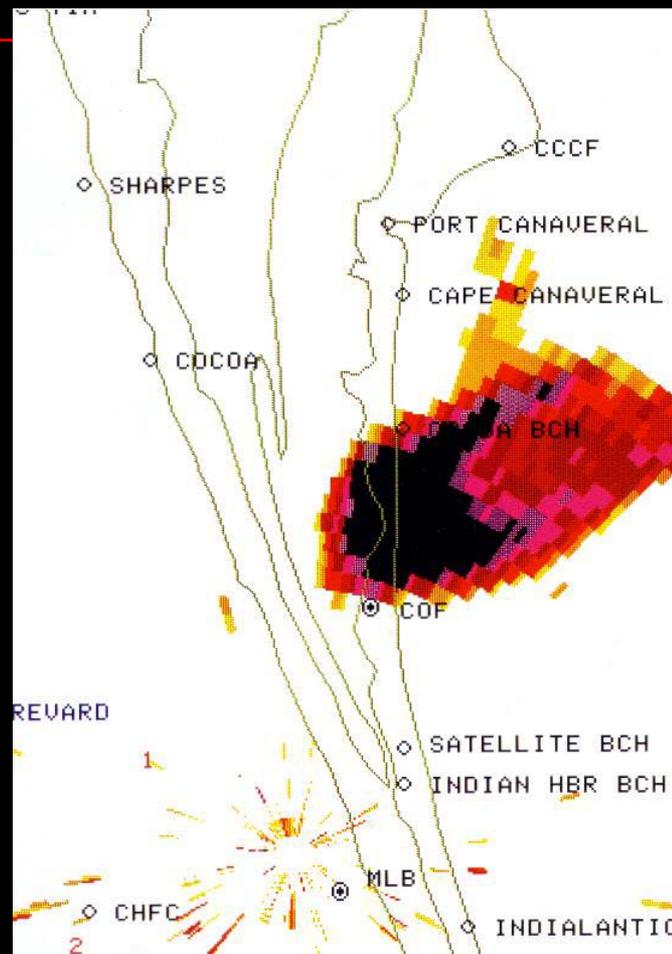
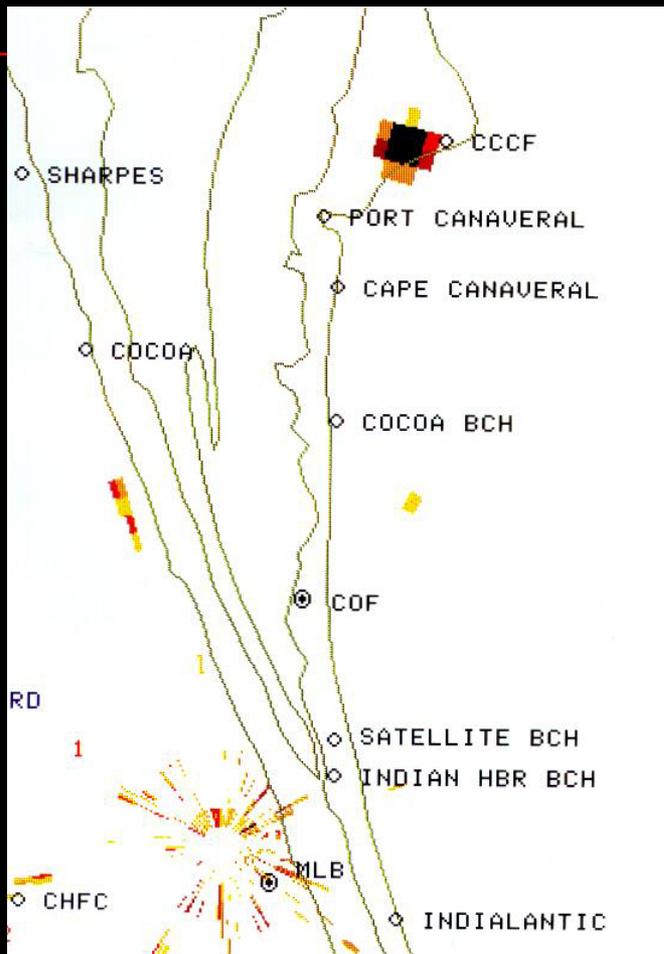
Cape Canaveral

Cocoa Beach

Doppler 9000 Radar Network

EYEWITNESS NEWS

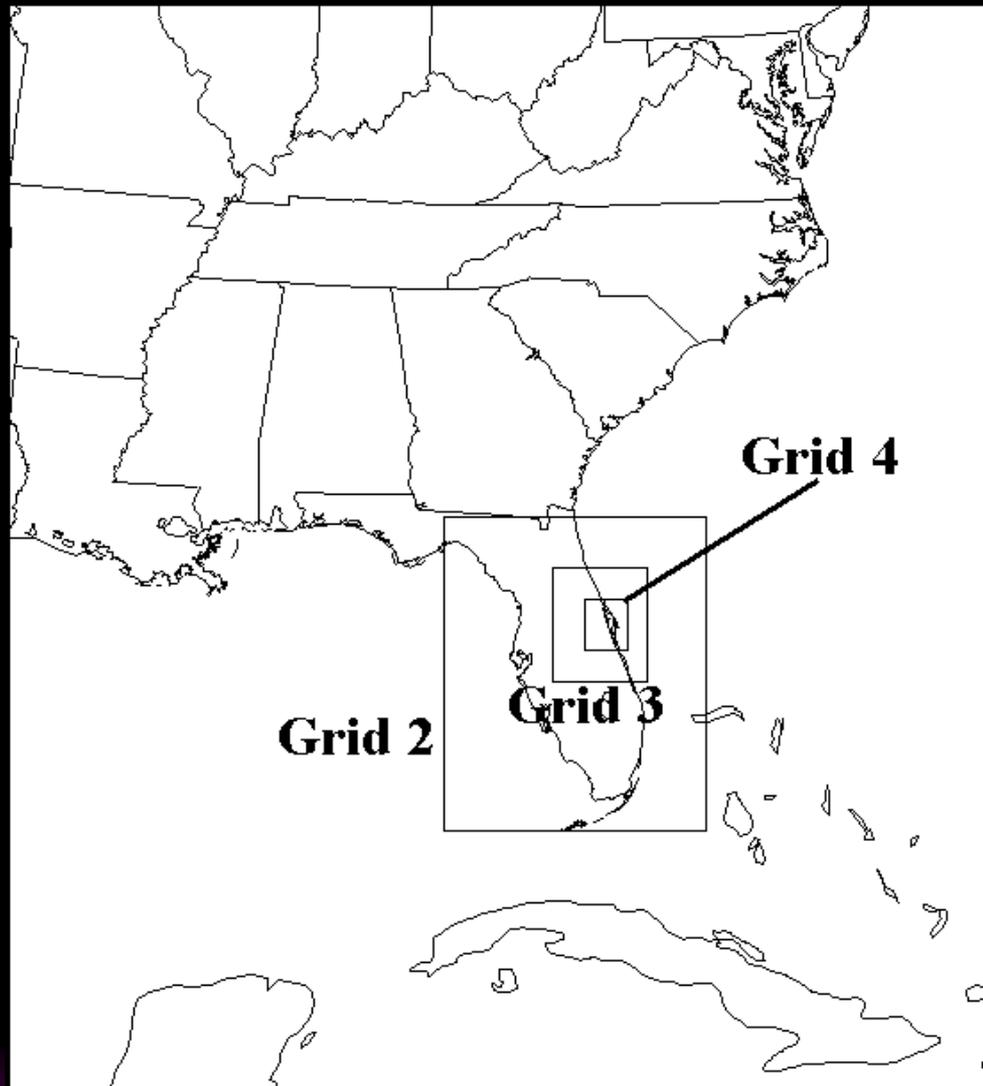




RAMS configuration (most recent)

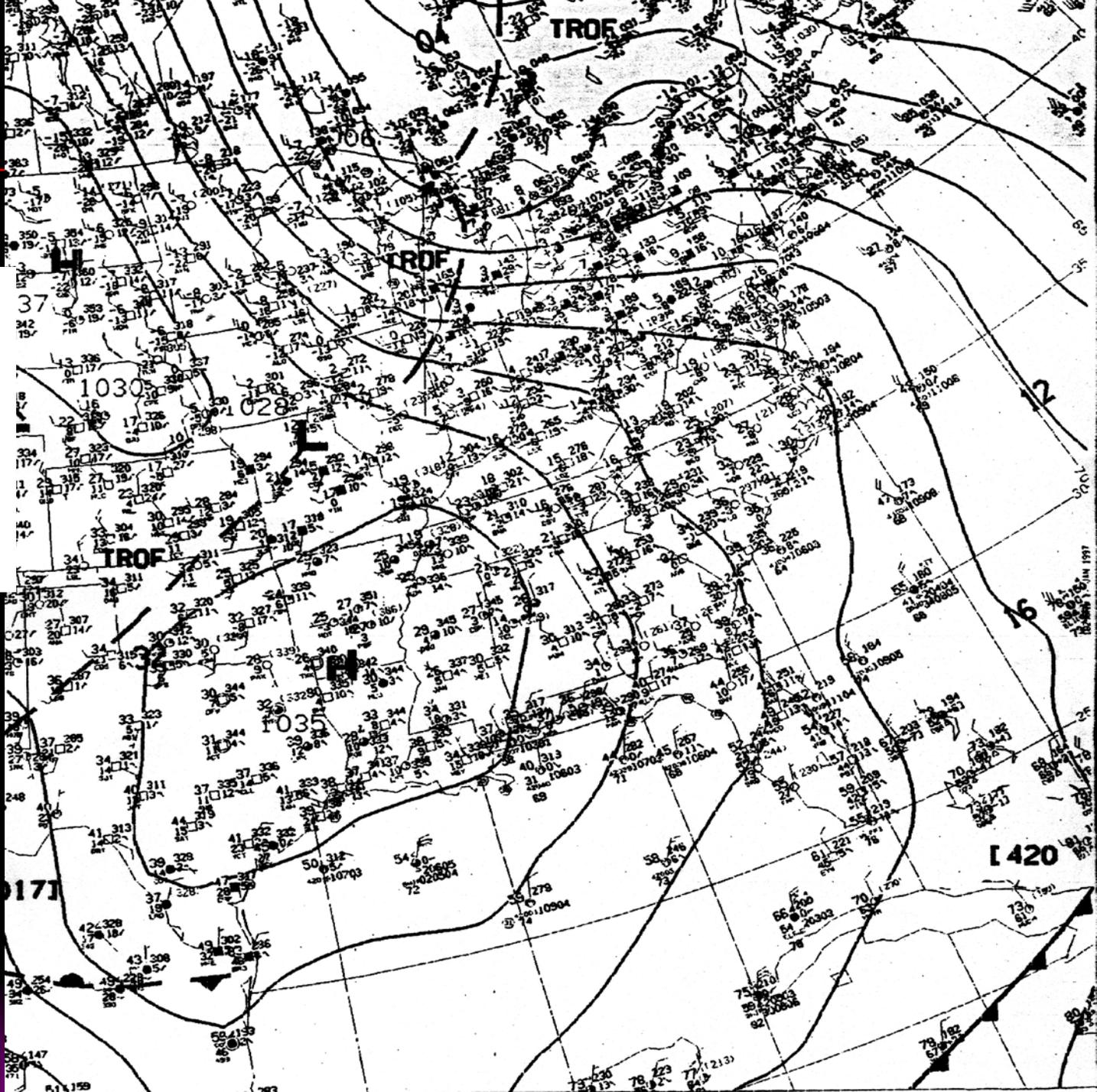
- Version 4a
- Run with microphysics
- 4 nested grids
- Fine horizontal grid: 1.25 km. spacing (61 x 85 km domain)
- Vertical grid: ~33 levels (25 m –
- Initialization: 0000 UTC and 1200 UTC with Eta forecast grids, NWS surface, buoys and rawinsondes, local tower network, wind profiler
- Output: hourly for 24 hours

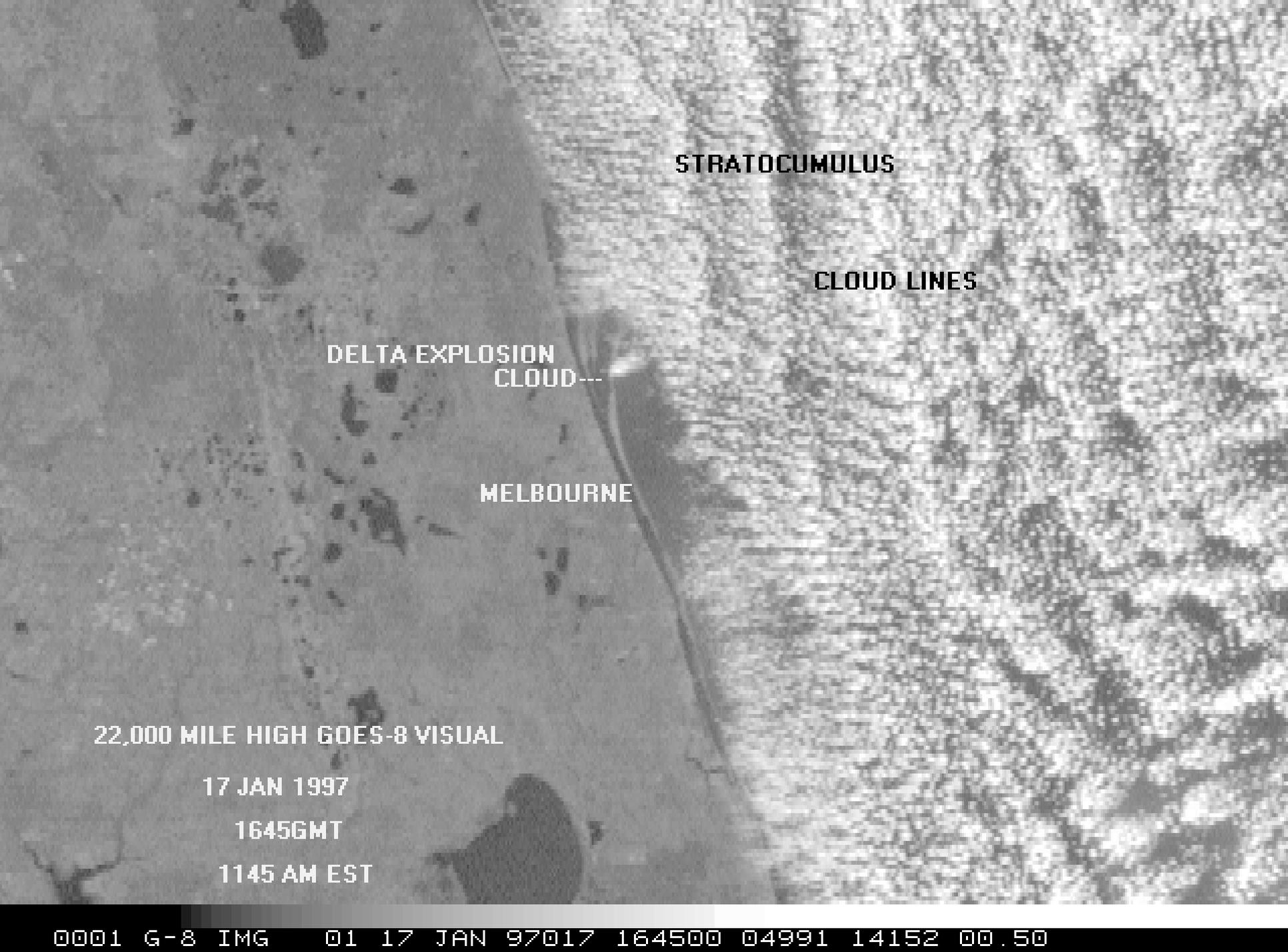
RAMS nested grids



Delta II case study: Meteorological observations

Surface
weather
map
17 Jan 1997



A satellite image showing a coastal region. The land is on the left, and the ocean is on the right. A large, dark, irregular cloud mass is visible over the land, labeled 'DELTA EXPLOSION CLOUD'. To the right of this cloud, there are several distinct, parallel cloud lines extending from the coast into the ocean, labeled 'CLOUD LINES'. Further out in the ocean, there are larger, more diffuse cloud areas labeled 'STRATOCUMULUS'. The city of Melbourne is indicated by a label on the coast.

STRATOCUMULUS

CLOUD LINES

DELTA EXPLOSION
CLOUD---

MELBOURNE

22,000 MILE HIGH GOES-8 VISUAL

17 JAN 1997

1645GMT

1145 AM EST

STRATOCUMULUS

17 JAN 1997

CLOUD

LINES

DELTA EXPLOSION CLOUD---

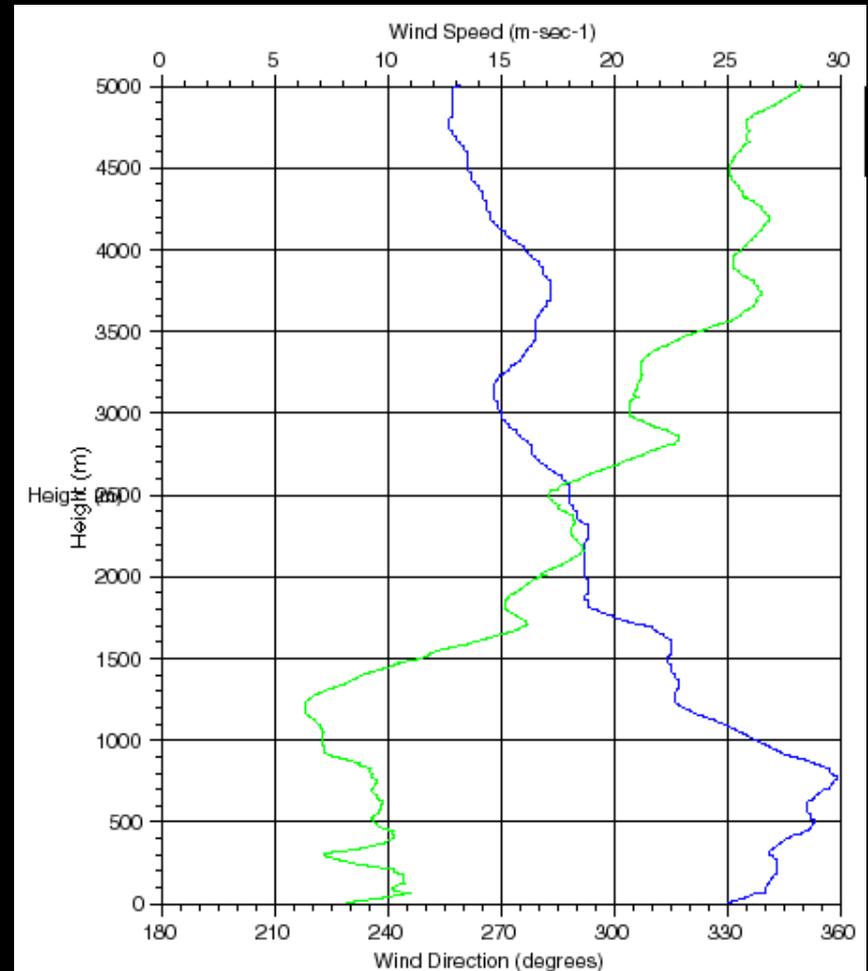
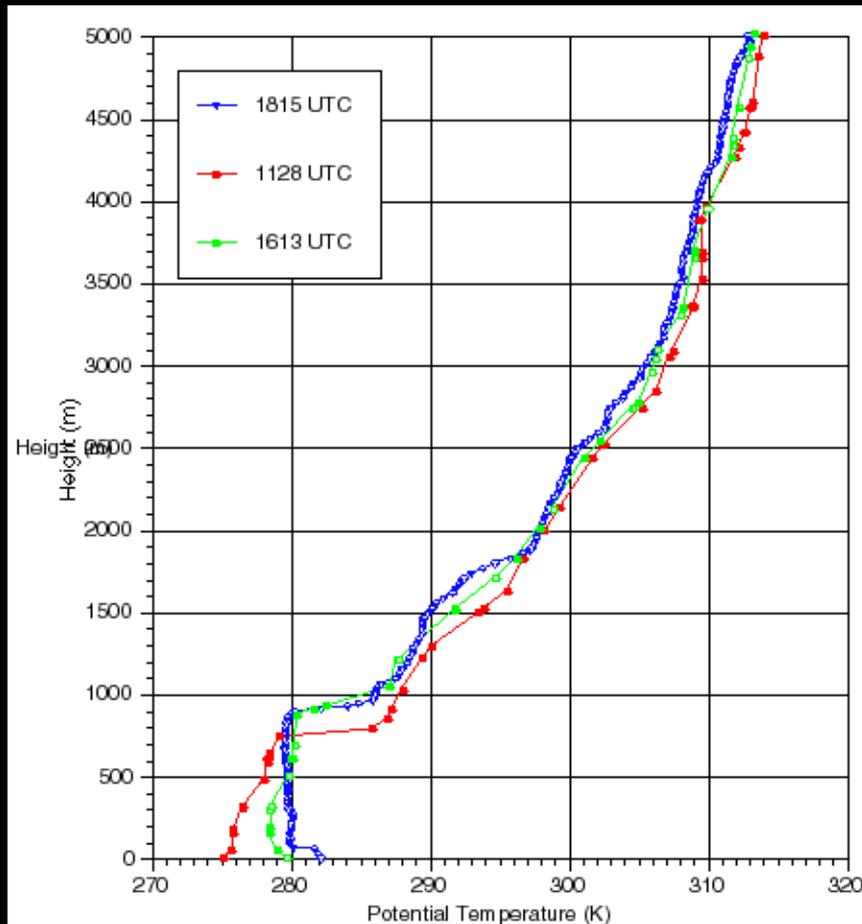
MELBOURNE

22,000 MILE HIGH GOES-8 VISUAL

1715 GMT

1215 AM EST

Profiles of θ , wind speed, wind direction

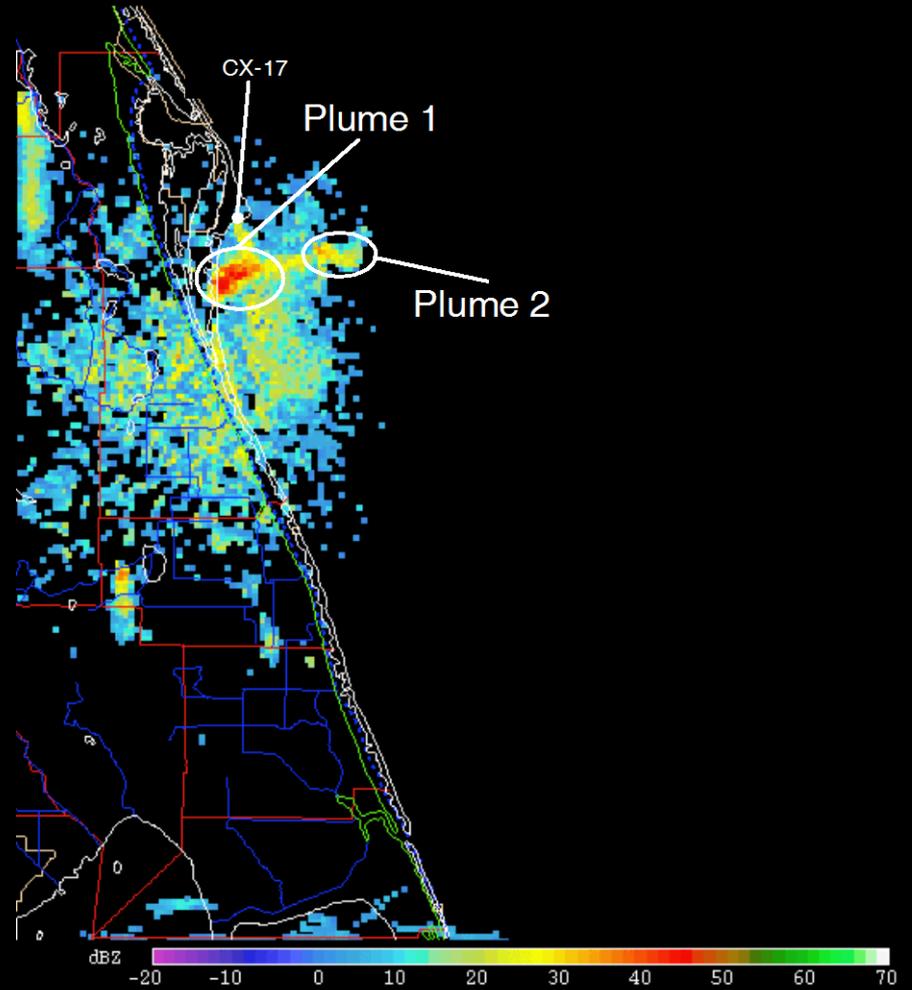
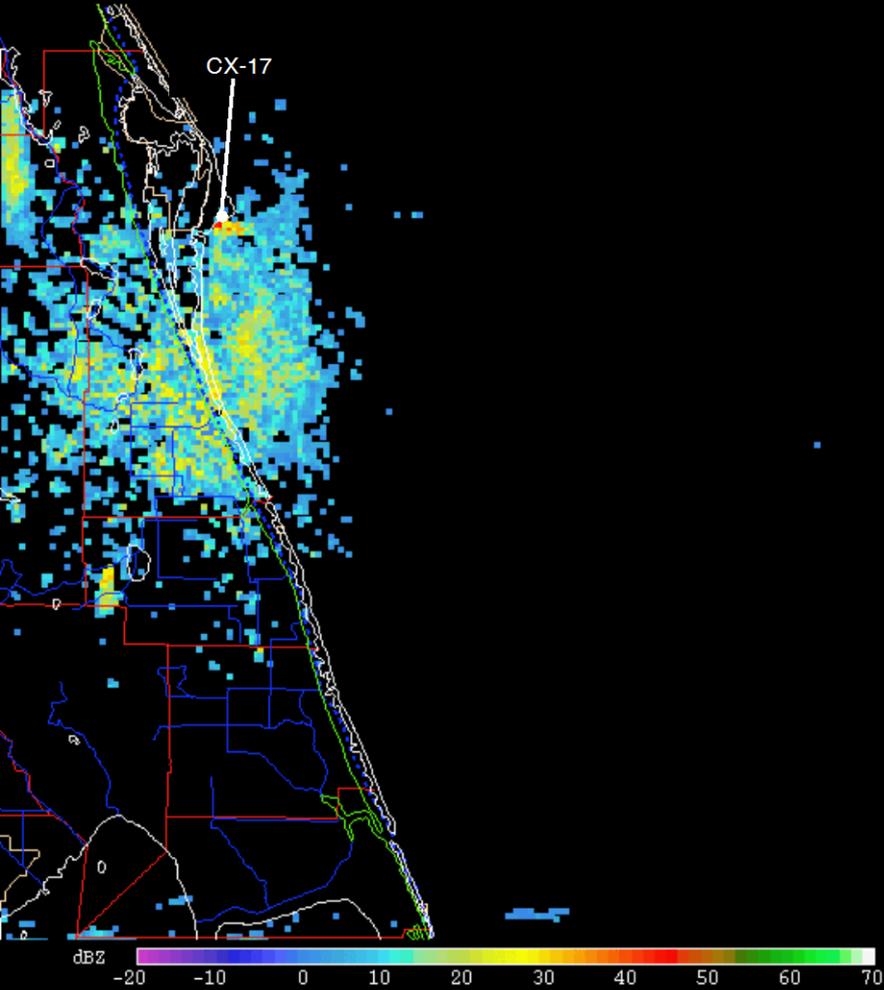


NWS Doppler radar

+3 min

+23 min

Radar: KMLB Site: Melbourne, FL Date: 01/17/1997 Time: 162552-163639 UTC El.Radar: KMLB Site: Melbourne, FL Date: 01/17/1997 Time: 164531-165616 UTC El.

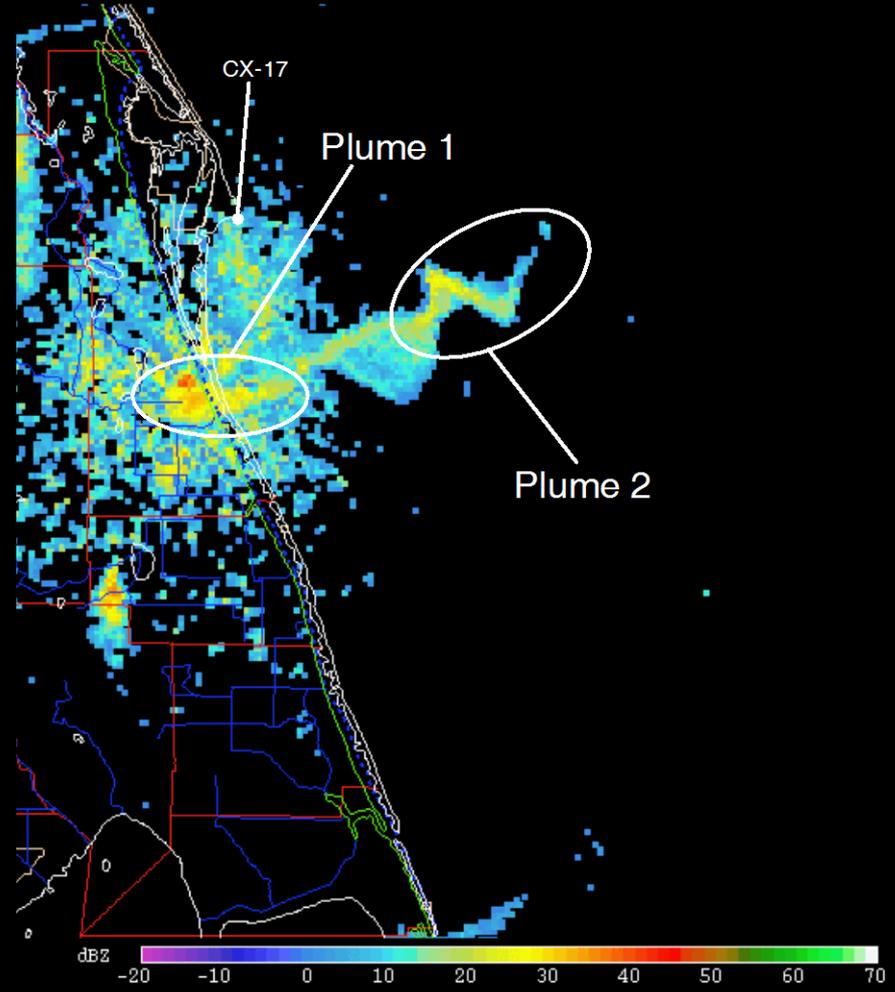
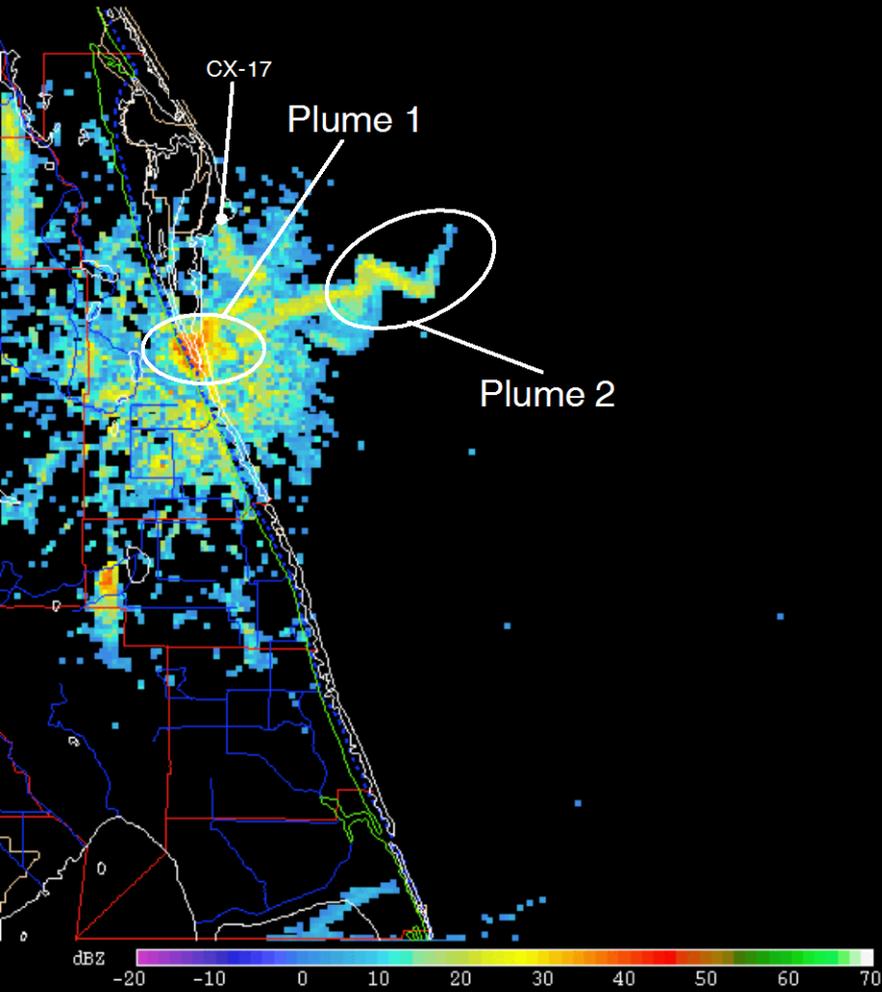


NWS Doppler radar

+38 min

+62 min

Radar: KMLB Site: Melbourne, FL Date: 01/17/1997 Time: 170538-171519 UTC El: 4.53 radar: KMLB Site: Melbourne, FL Date: 01/17/1997 Time: 172515-173455 UTC

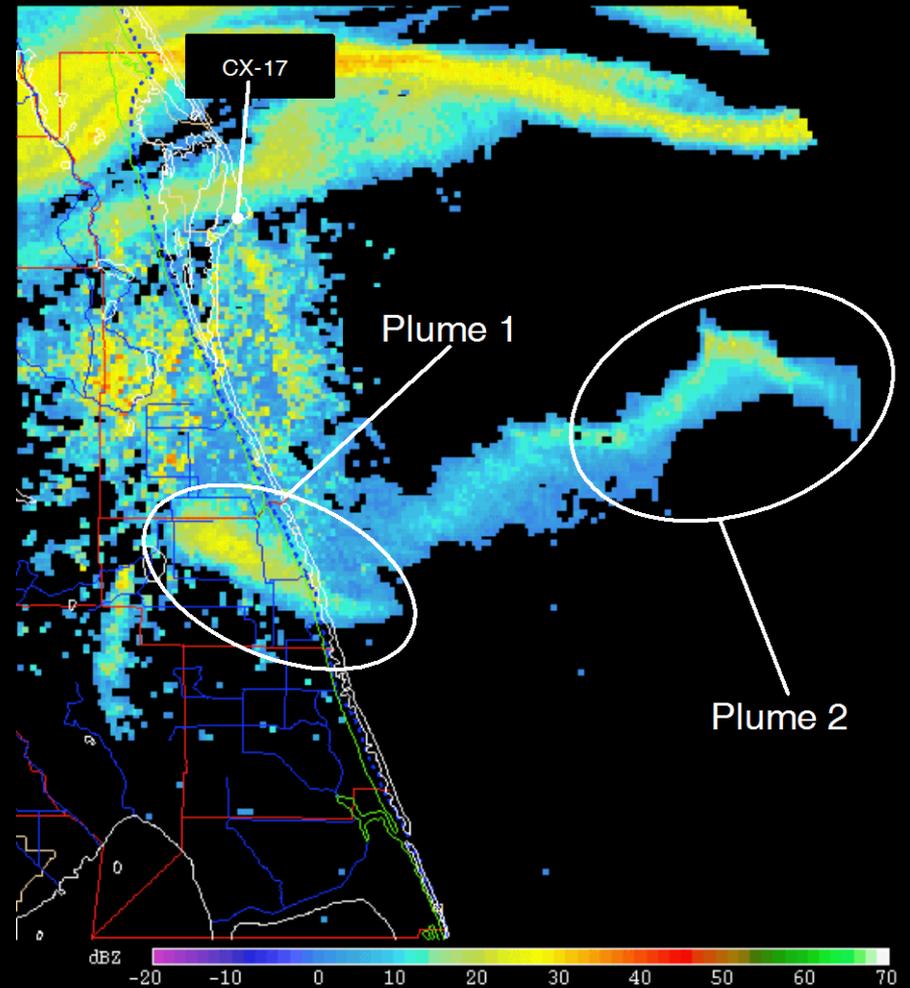
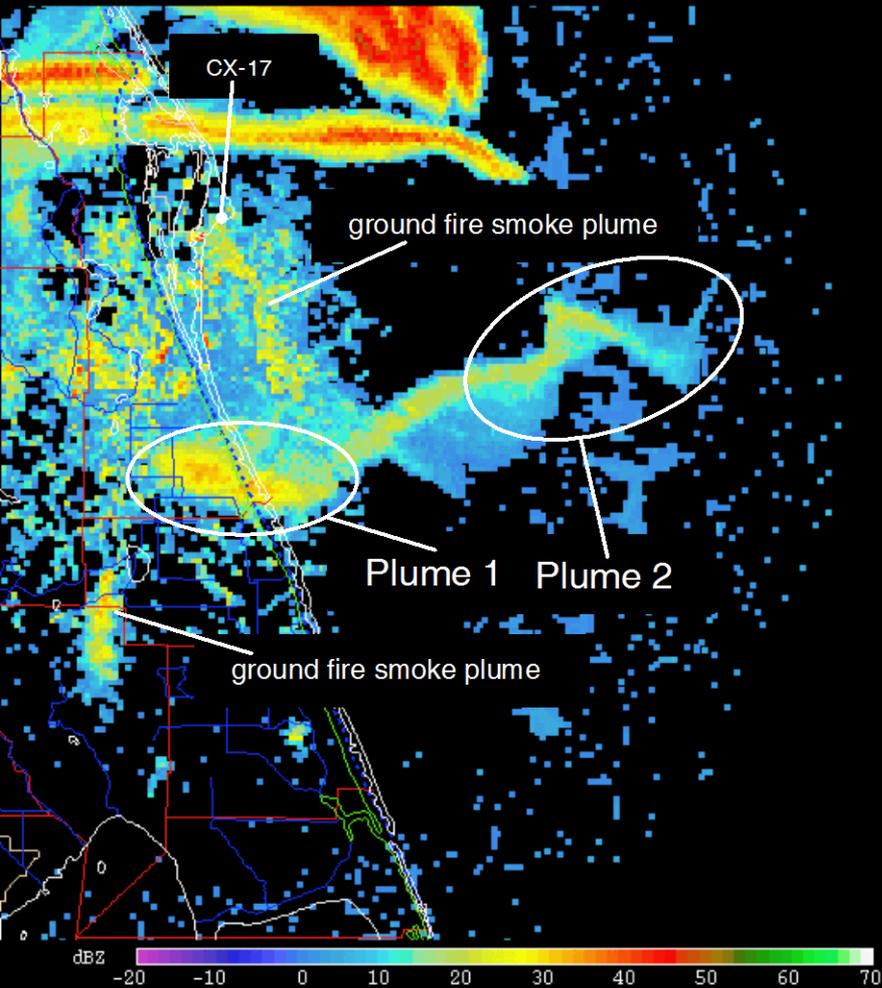


NWS Doppler radar

+101 min

+140 min

Radar: KMLB Site: Melbourne, FL Date: 01/17/1997 Time: 180428-181407 UTC El. Radar: KMLB Site: Melbourne, FL Date: 01/17/1997 Time: 184341-185320 UTC El.

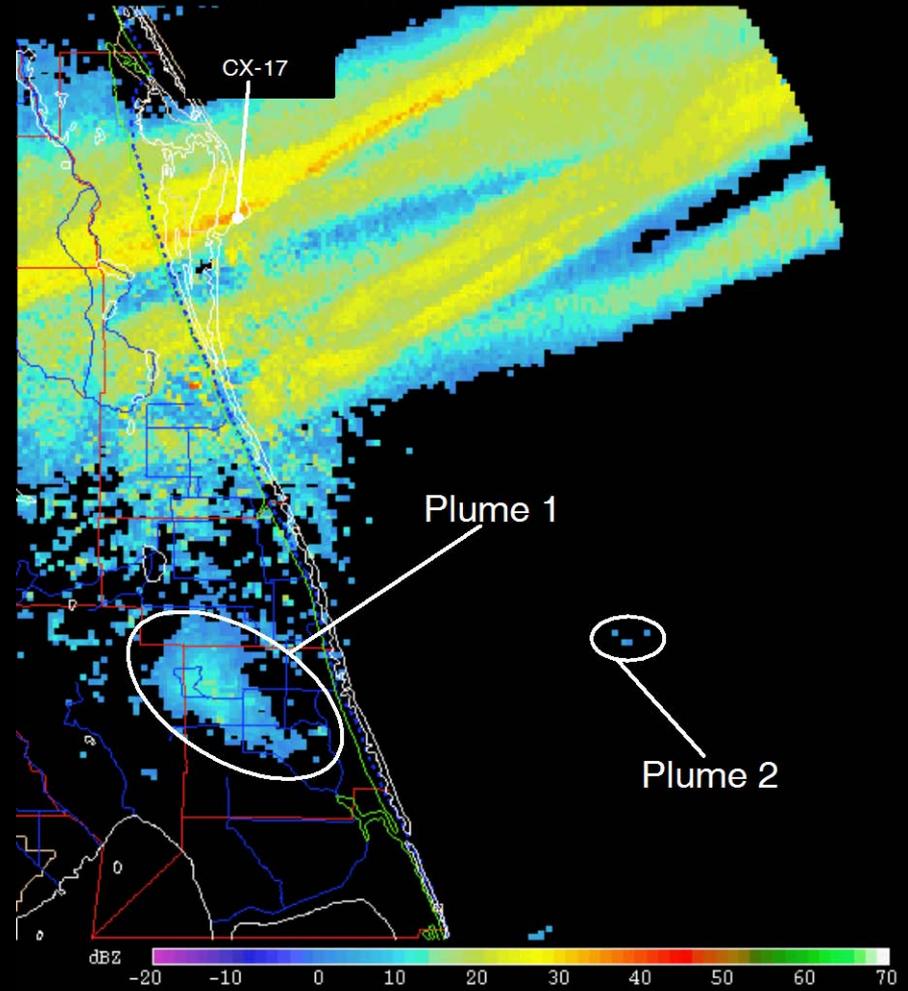
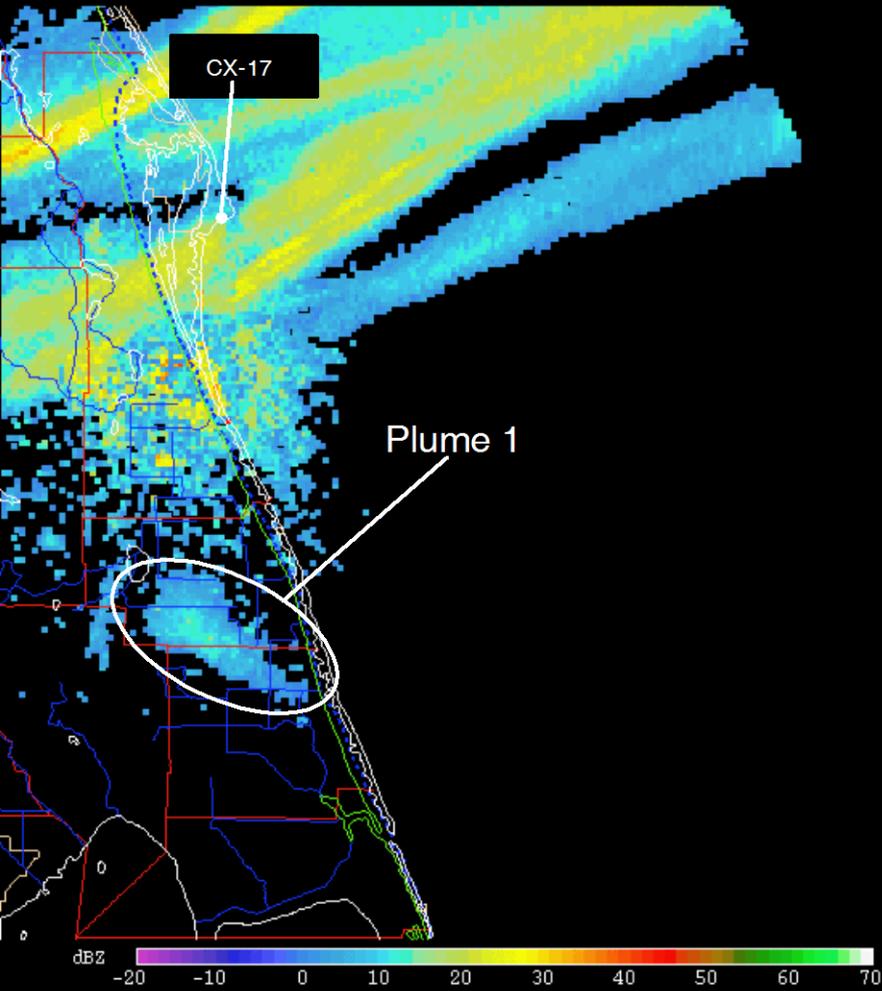


NWS Doppler radar

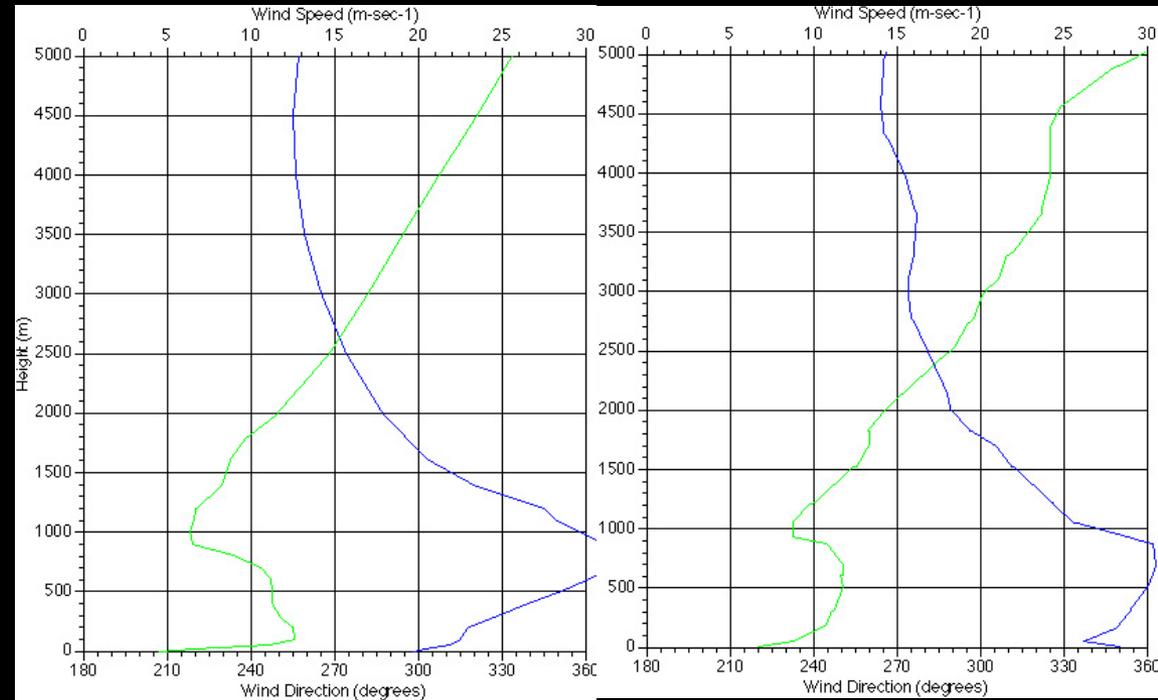
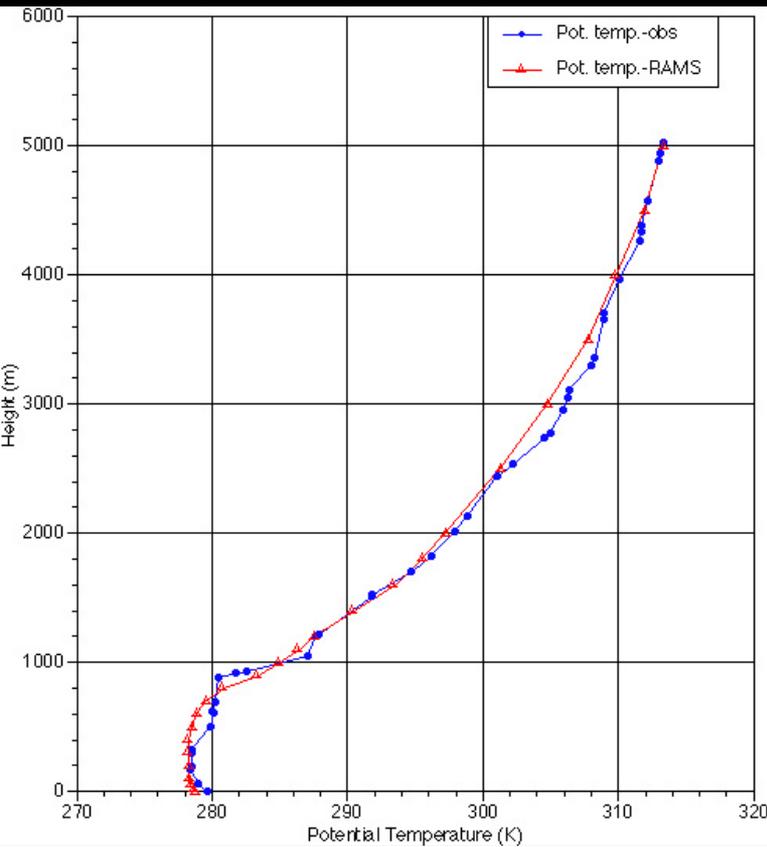
+199 min

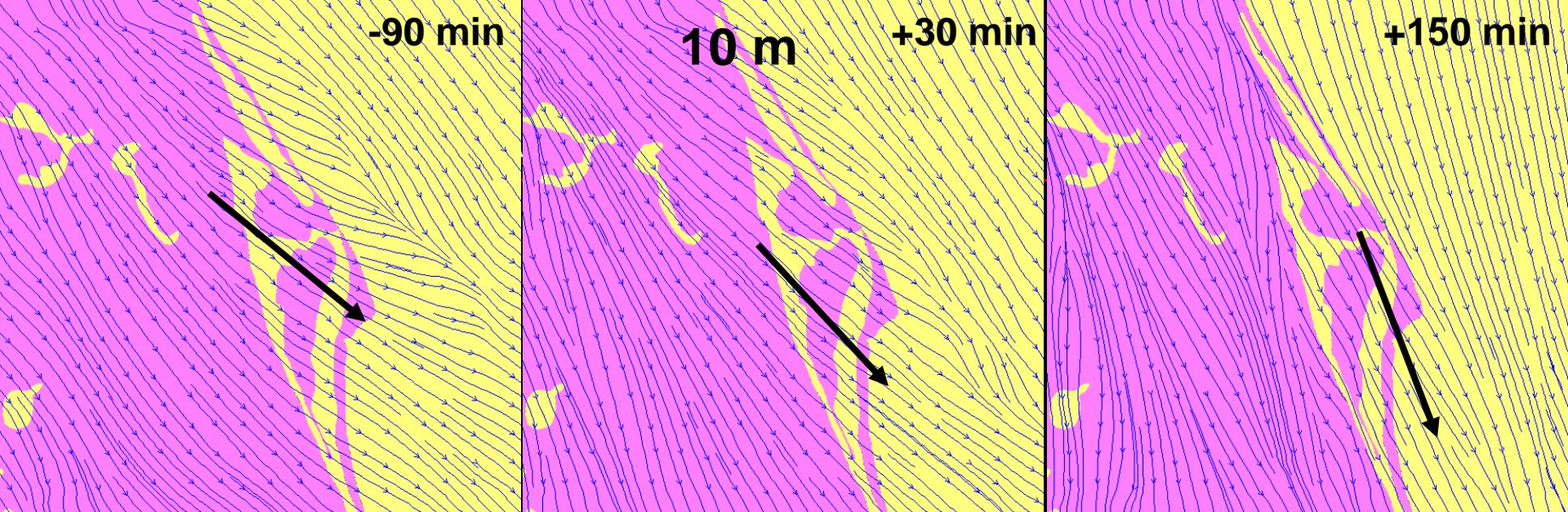
+239 min

Radar: KMLB Site: Melbourne, FL Date: 01/17/1997 Time: 194231-195316 UTC El: Radar: KMLB Site: Melbourne, FL Date: 01/17/1997 Time: 202144-203230 UTC E

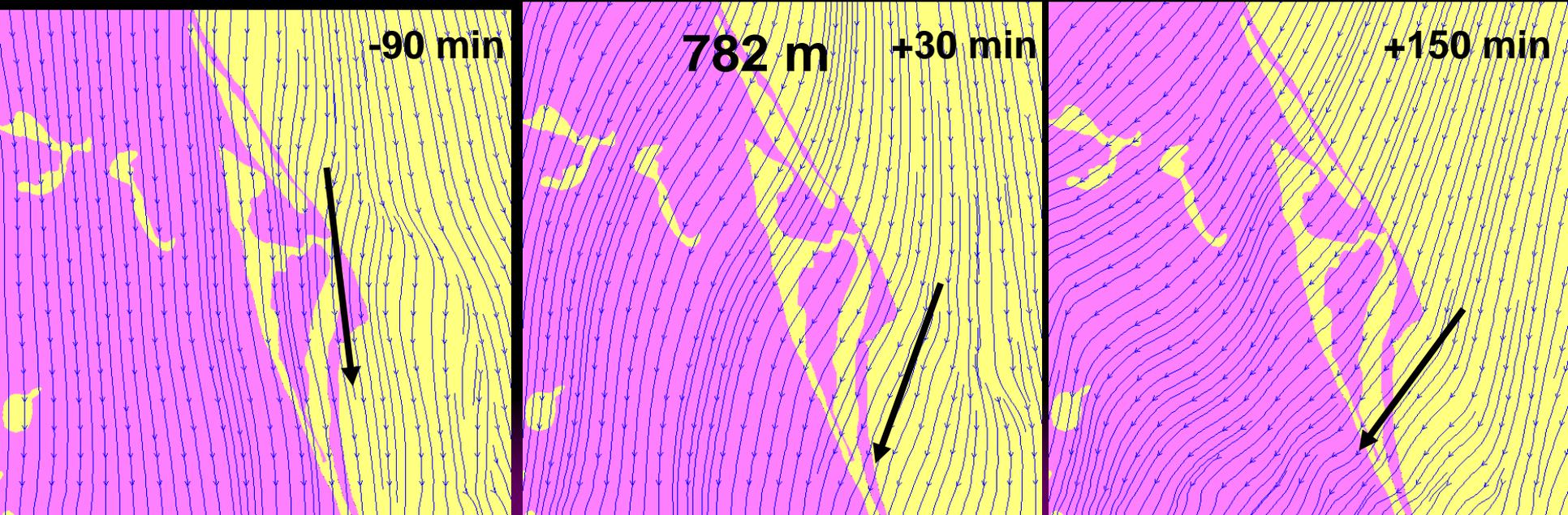


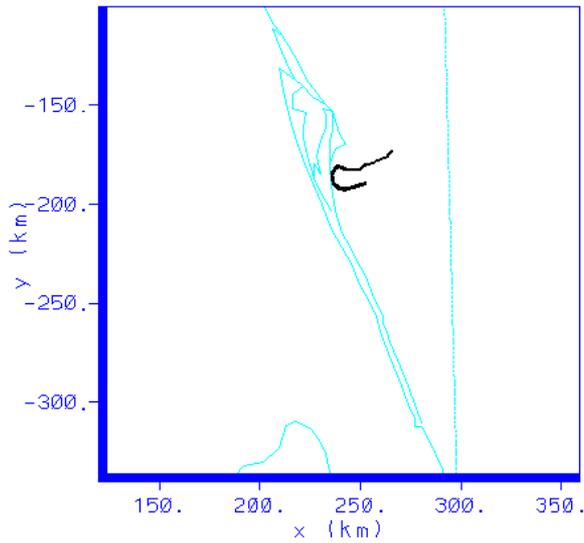
Delta II : RAMS predictions vs. obs of θ , wind speed, wind direction





RAMS predictions



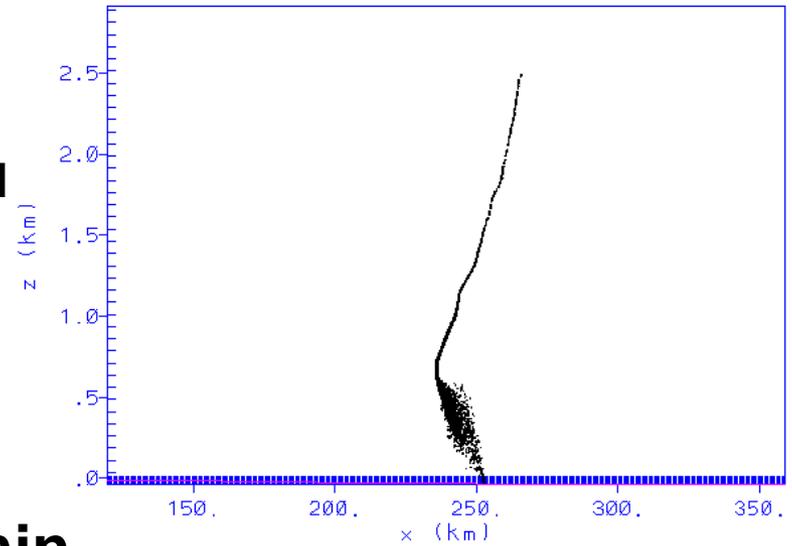


**REEDM
source
term**

+30 min

$z = 187.5 \text{ m}$

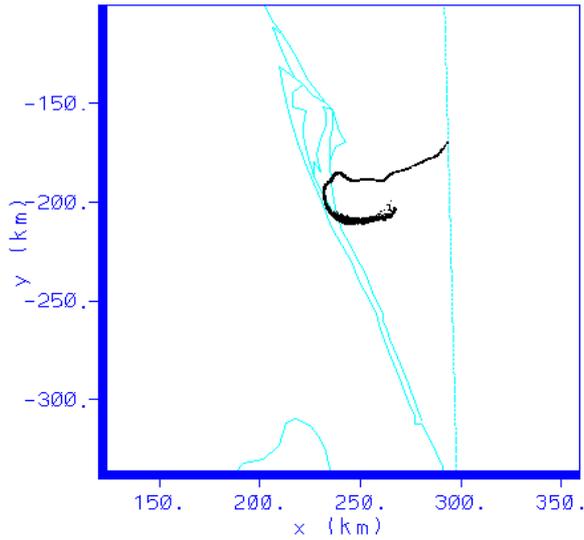
1700 UTC



$y = -280.43 \text{ km}$

1700 UTC

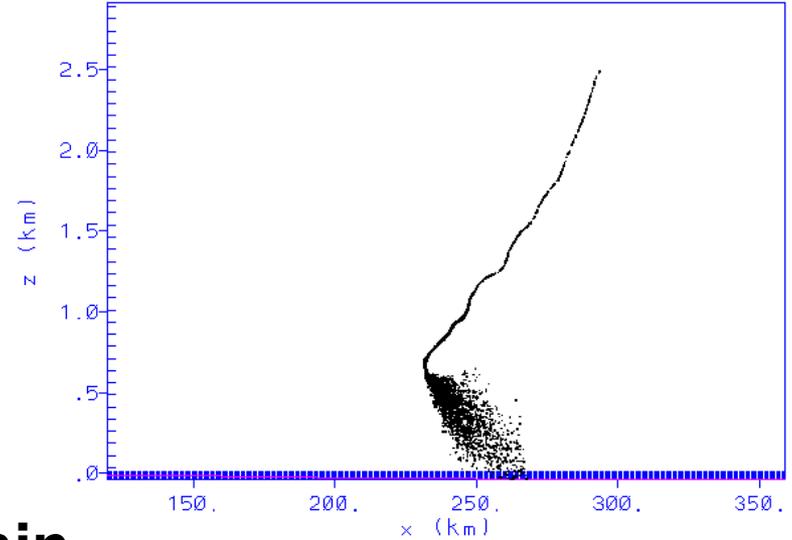
HYPACT predictions



+60 min

$z = 187.5 \text{ m}$

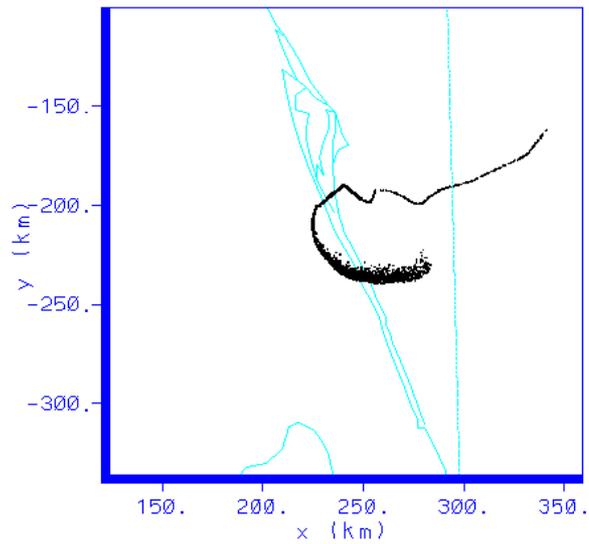
1730 UTC



$y = -280.43 \text{ km}$

1730 UTC

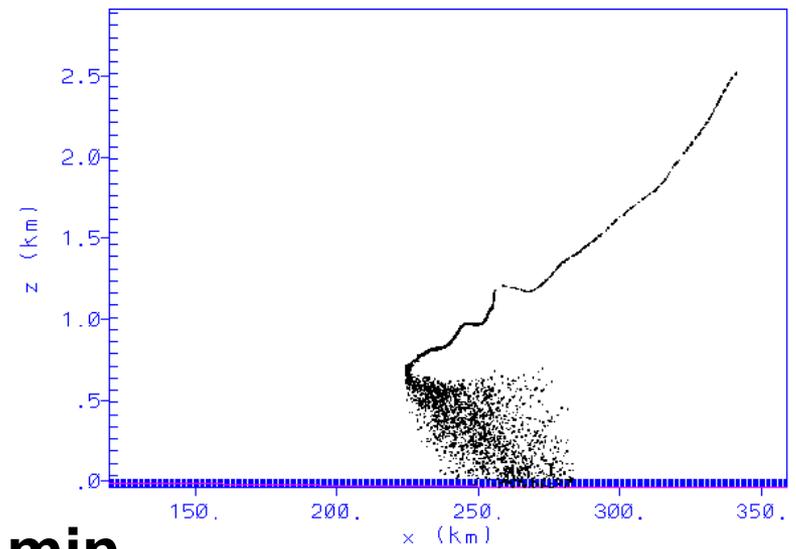




z = 187.5 m

1820 UTC

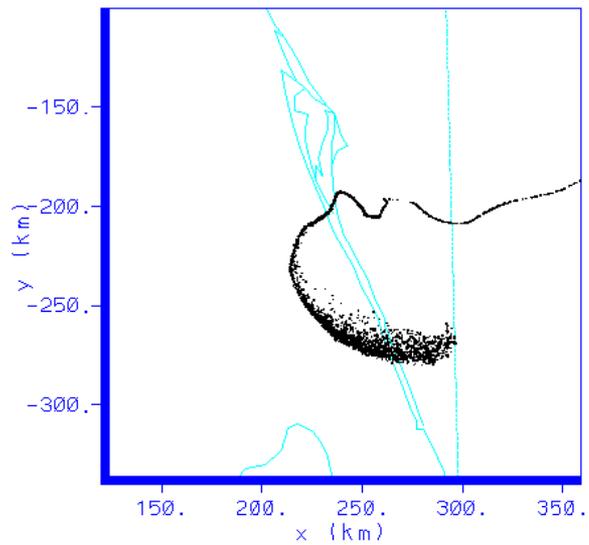
+110 min



y = -280.43 km

1820 UTC

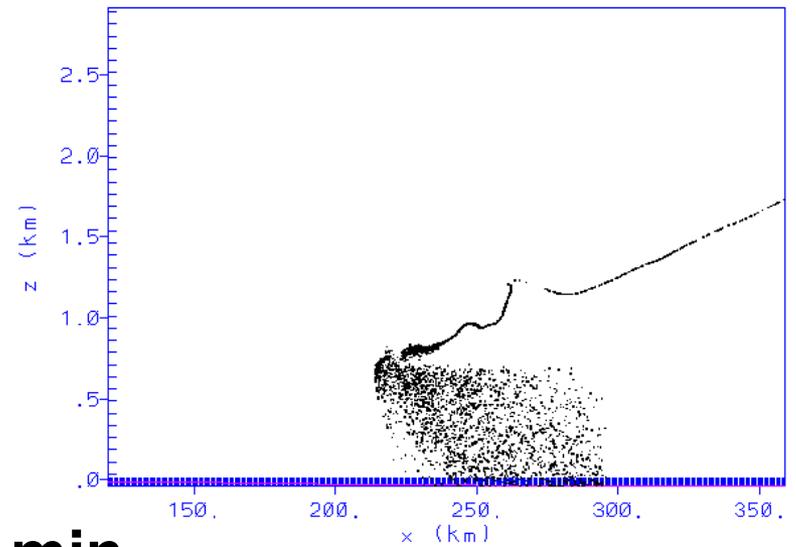
HYPACT predictions



z = 187.5 m

1930 UTC

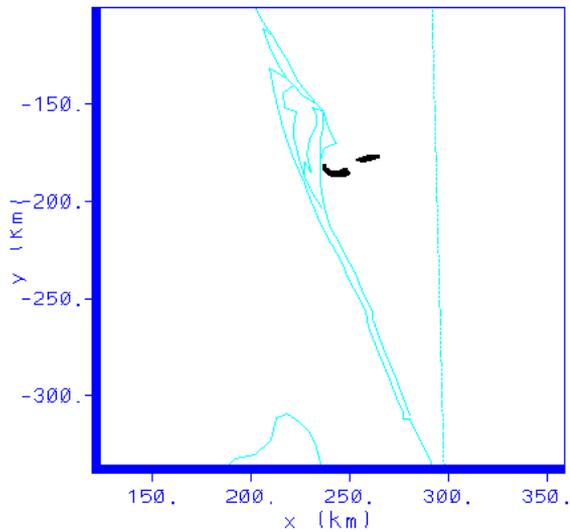
+180 min



y = -280.43 km

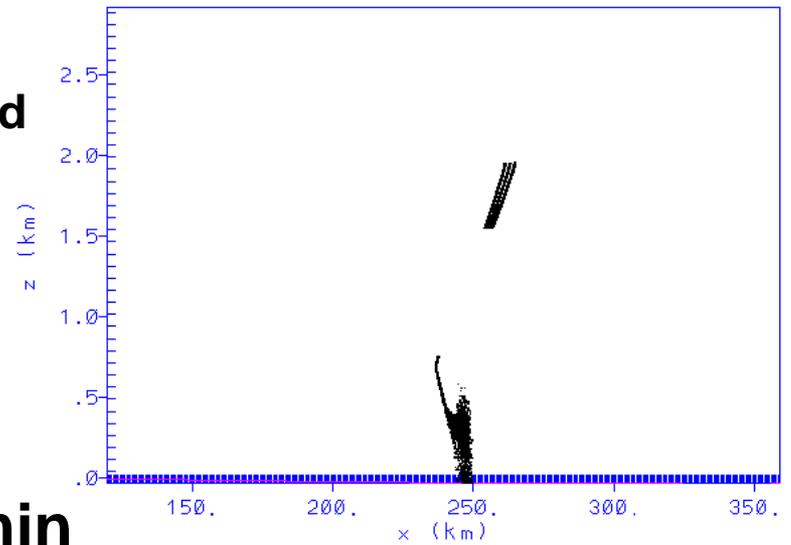
1930 UTC





**Modified
source
term**

+30 min

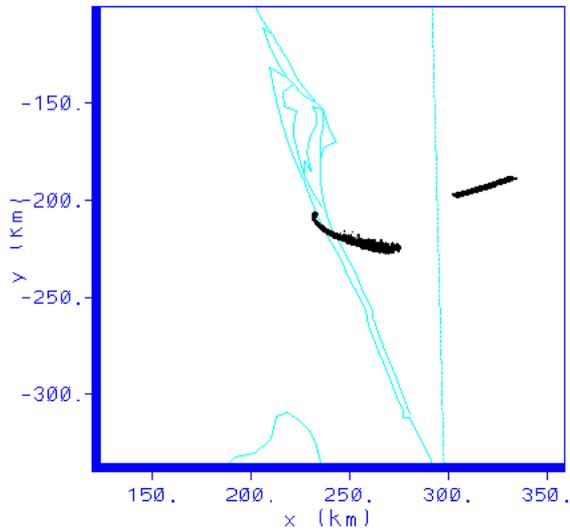


$z = 187.5 \text{ m}$

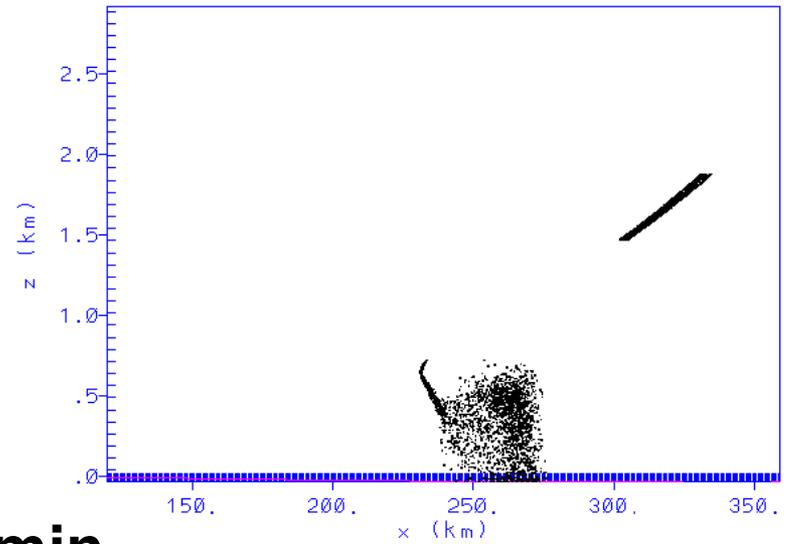
HYPACT predictions

280.43 km

1700 UTC



+110 min



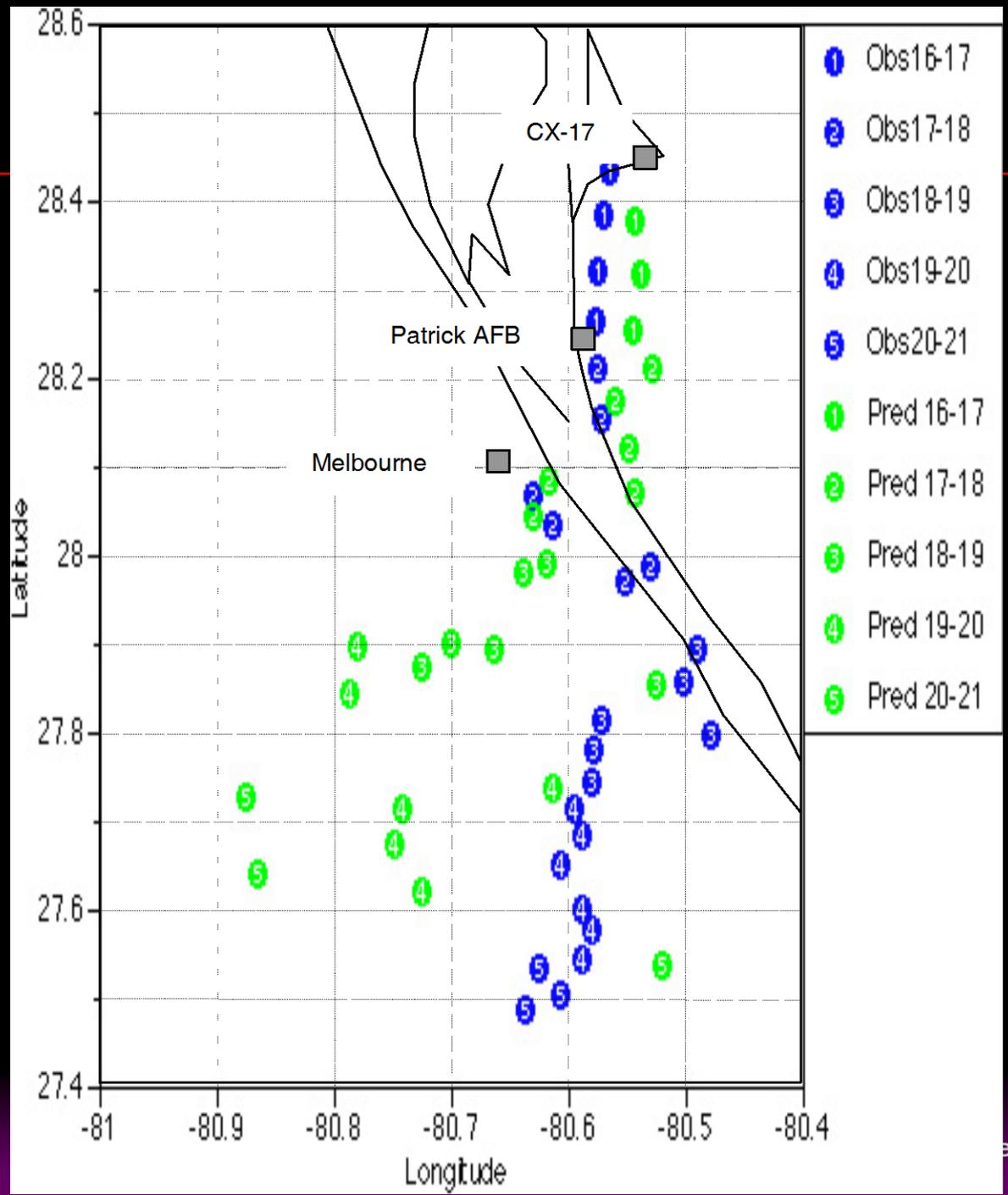
$z = 187.5 \text{ m}$

1820 UTC

$y = -280.43 \text{ km}$

1820 UTC

Observed vs. Predicted Plume 1 Center point



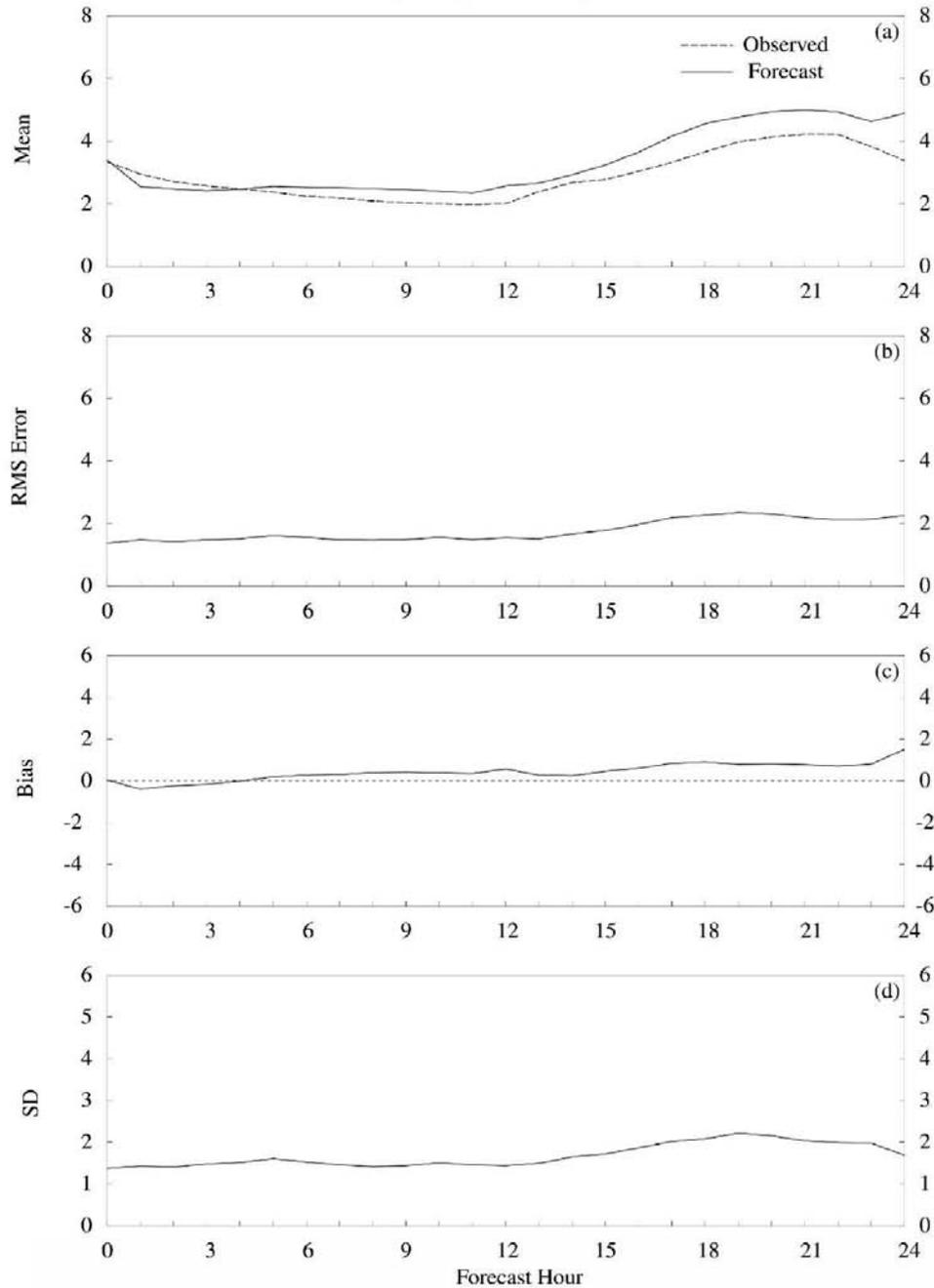
Subjective RAMS evaluation in ERDAS

- Computed point error statistics of
 - Root Mean Square (RMS) error
 - Bias
 - Error standard deviation
- Parameters verified included:
 - Surface wind
 - Thunderstorm days
 - Fine vs. coarse grids
 - RAMS vs. Eta model

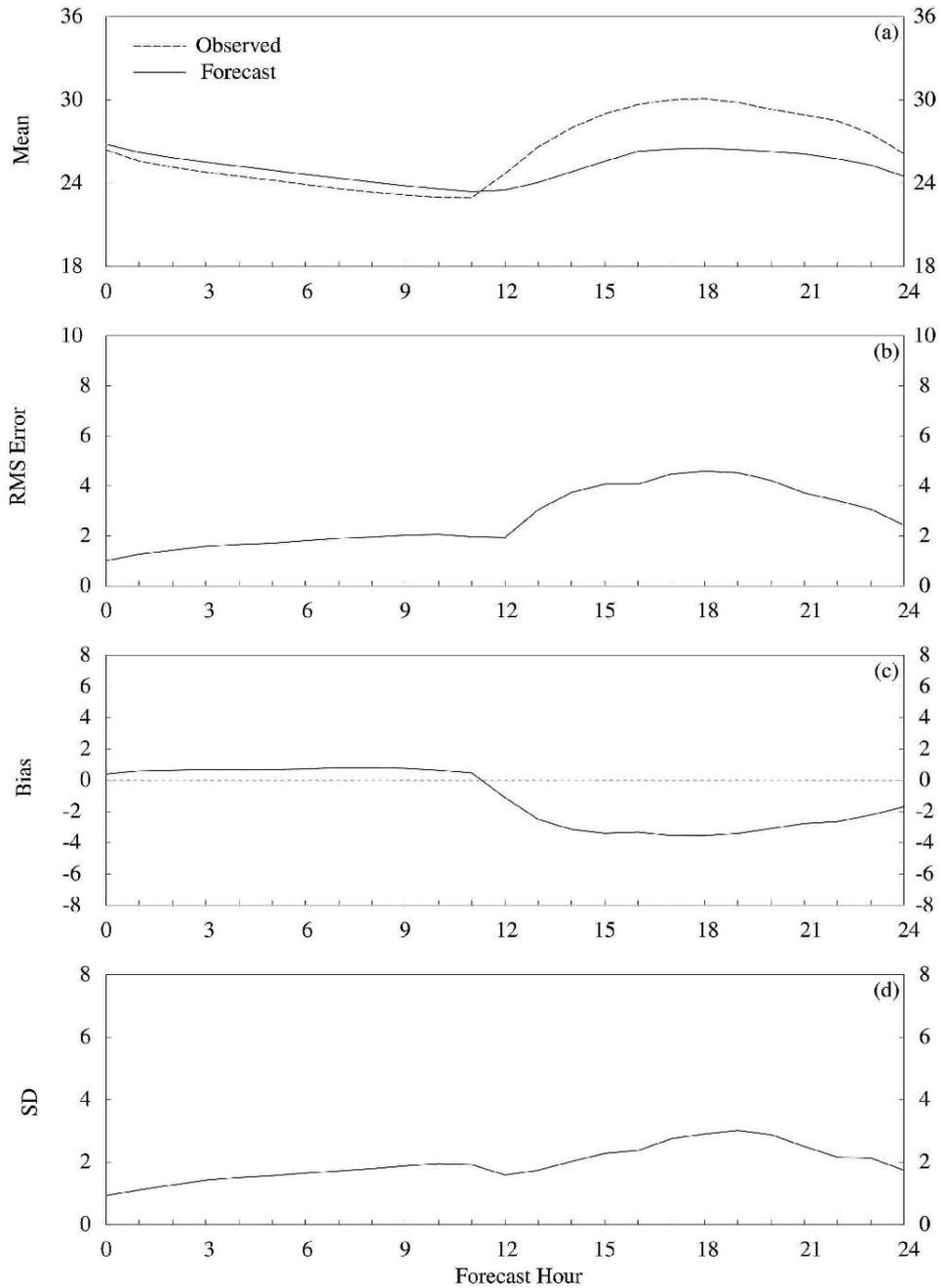
Objective RAMS evaluation in ERDAS

- Verification of fronts
- Precipitation across Florida peninsula and local to Cape Canaveral
- Occurrence and strength of low-level inversions
- Sea breeze occurrence and timing
- Thunderstorm initiation

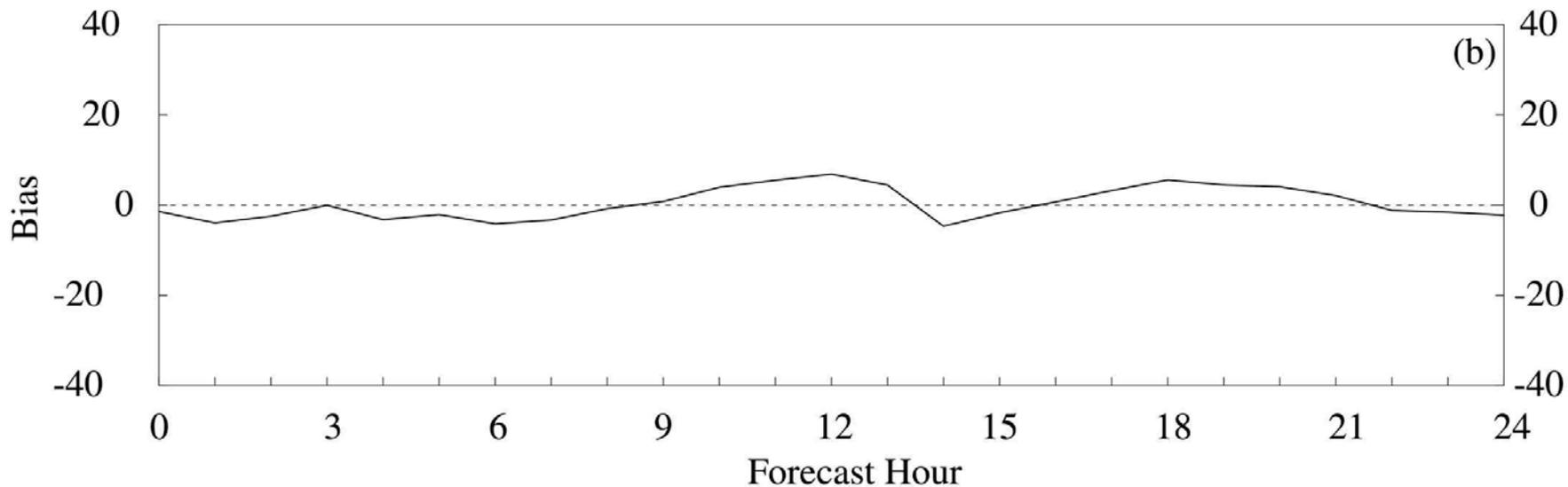
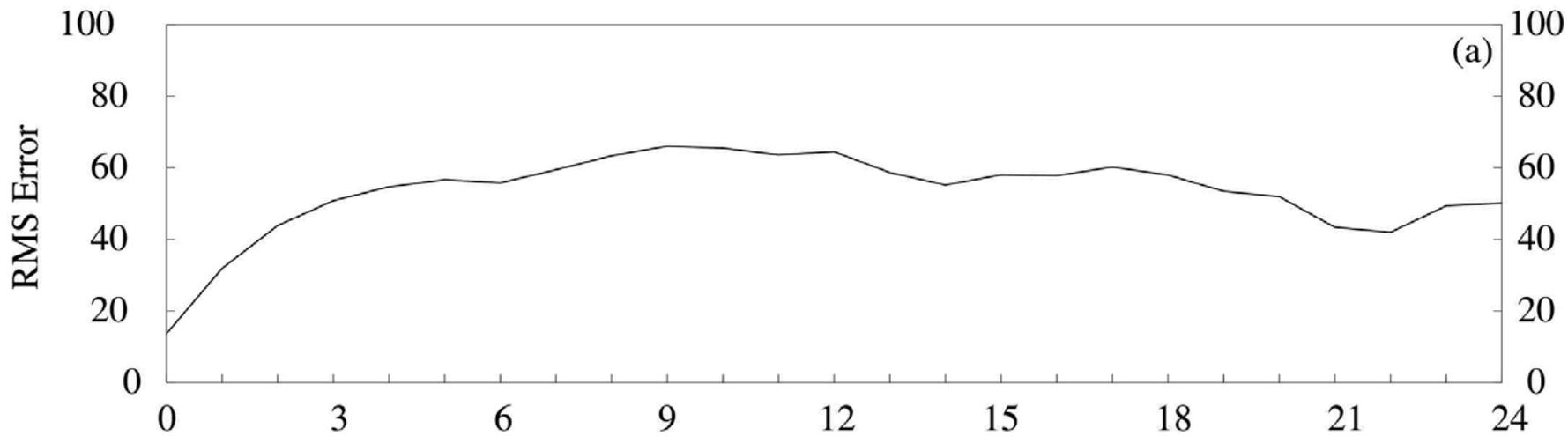
0000 UTC 4-grid Cycle Wind Spd (m/s) for 16.5-m towers



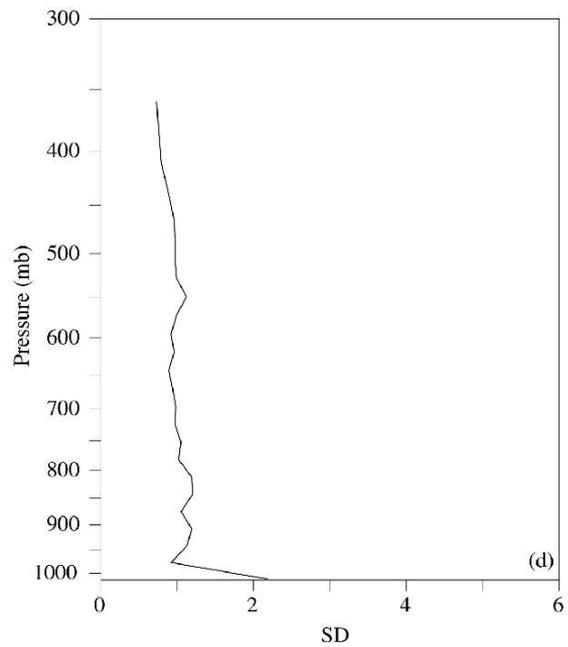
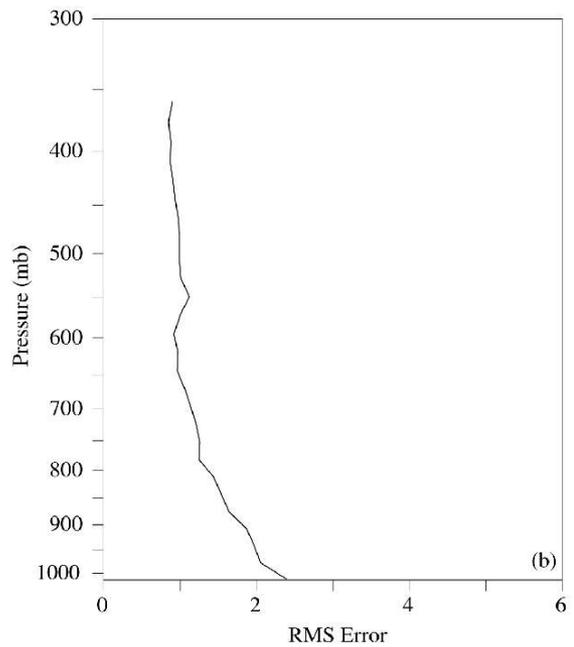
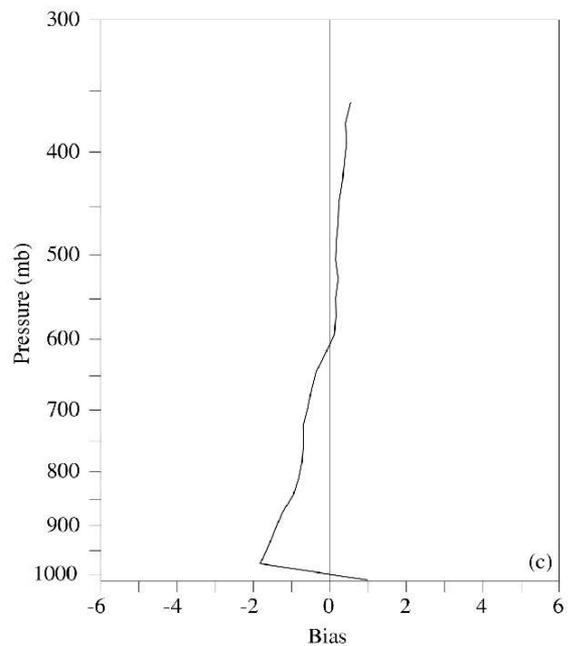
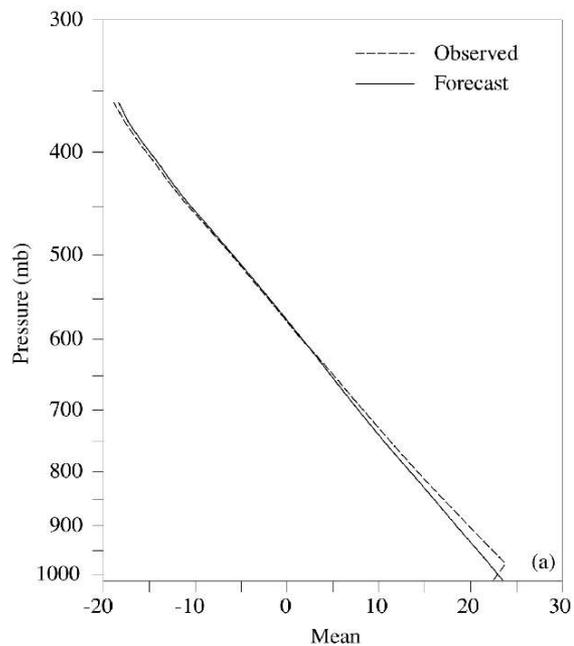
0000 UTC 4-grid Cycle Temperature (C) for 1.8-m towers



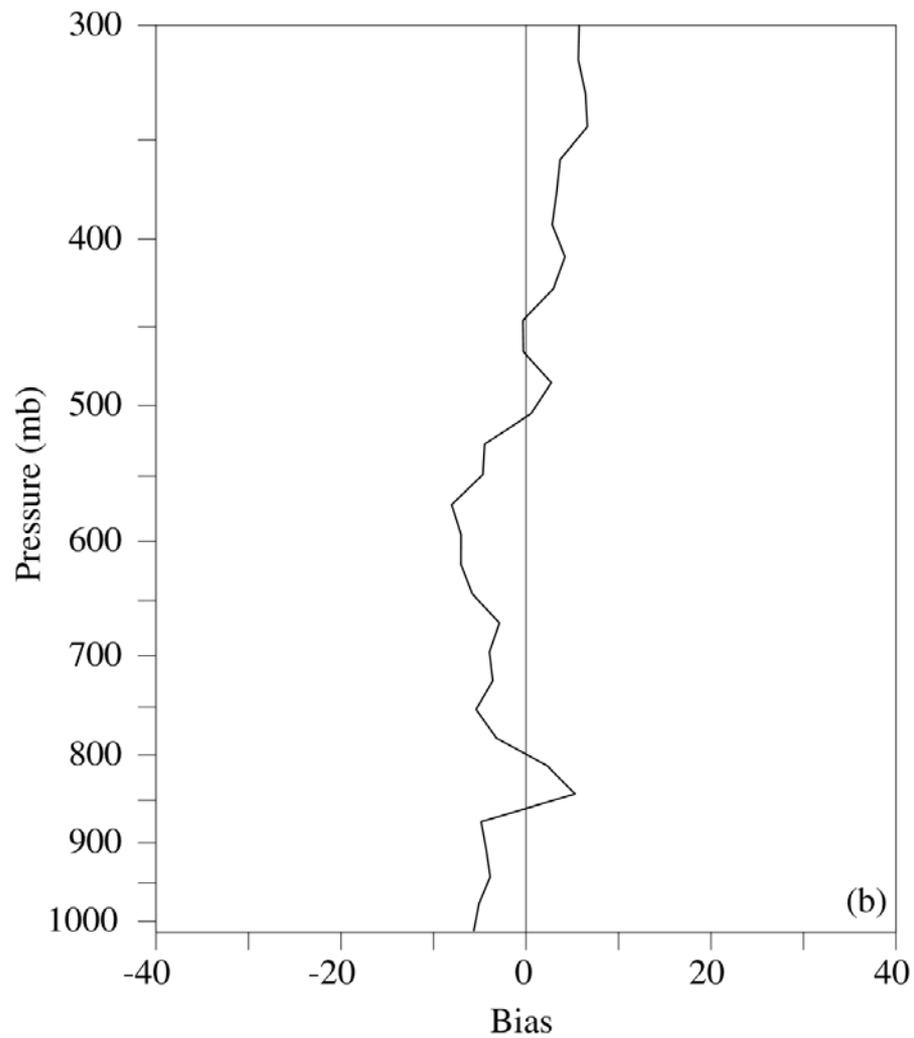
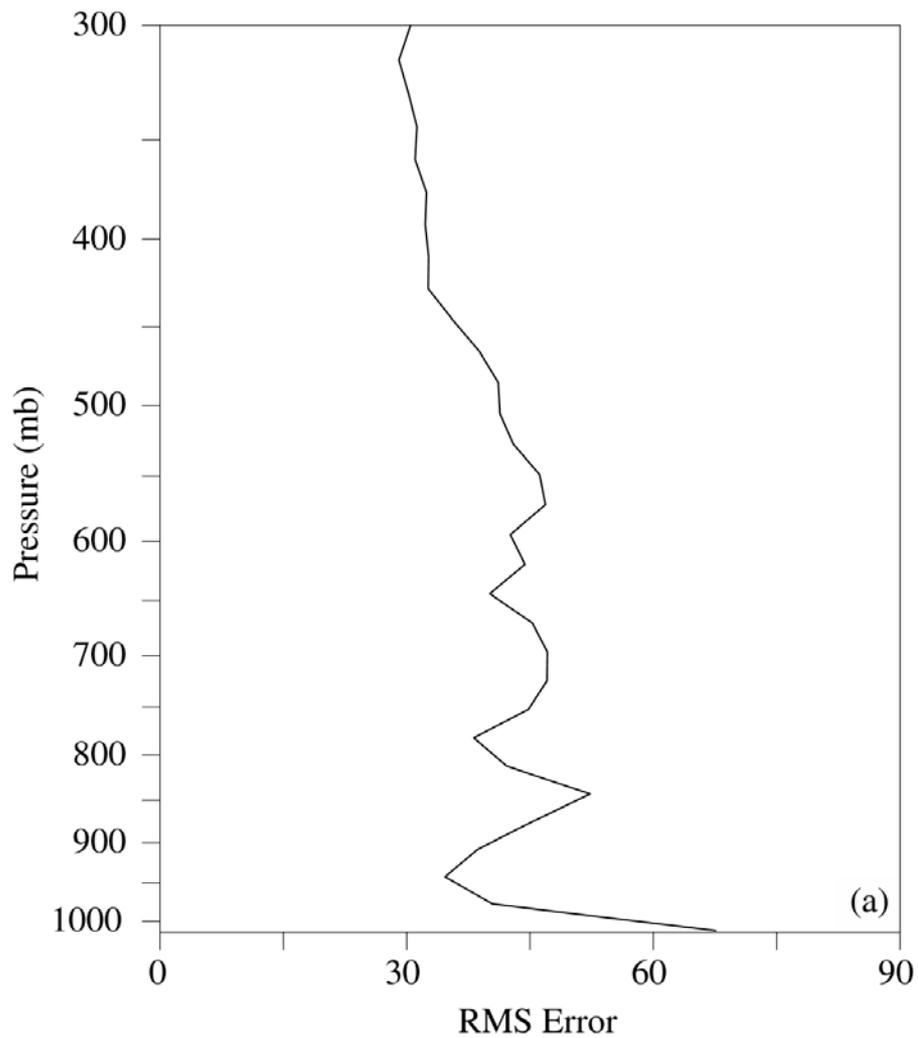
0000 UTC 4-grid Cycle Wind Dir (deg) for 16.5-m towers



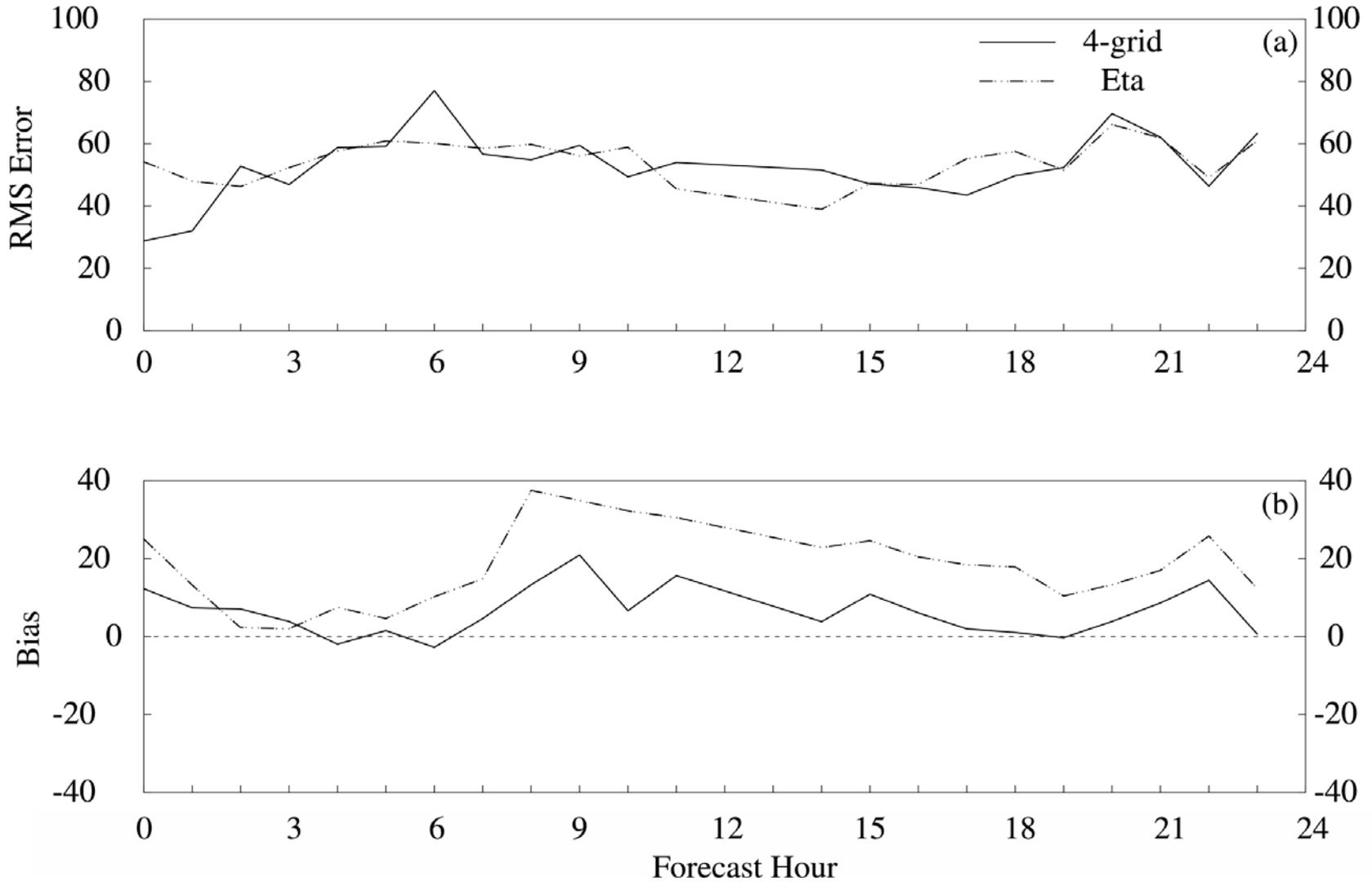
0000 UTC 4-grid Cycle 11-h Temp (C) at XMR



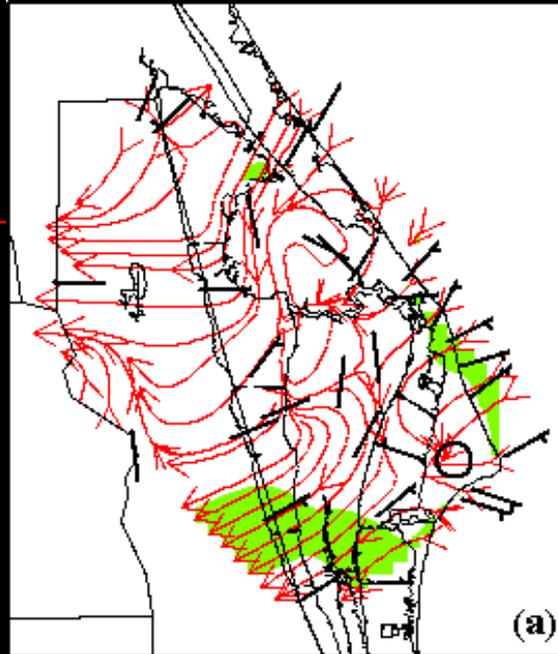
0000 UTC 4-grid Cycle 11-h Wind Dir (deg) at XMR



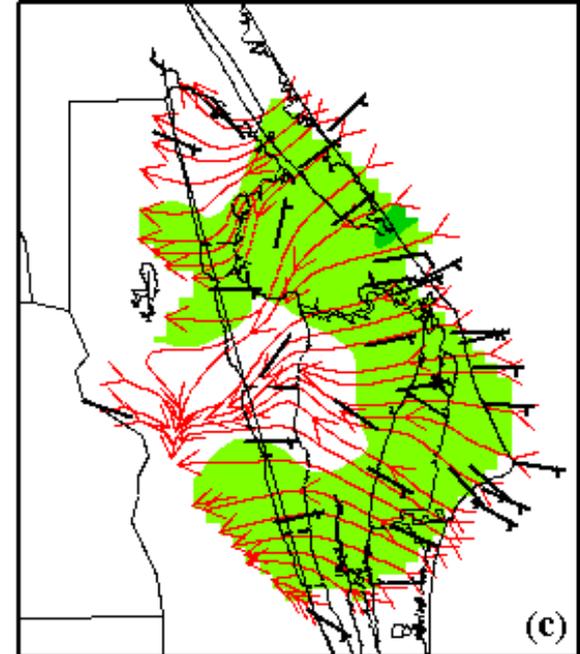
1200 UTC Eta/4-grid Cycle Wind Dir (deg) for TTS



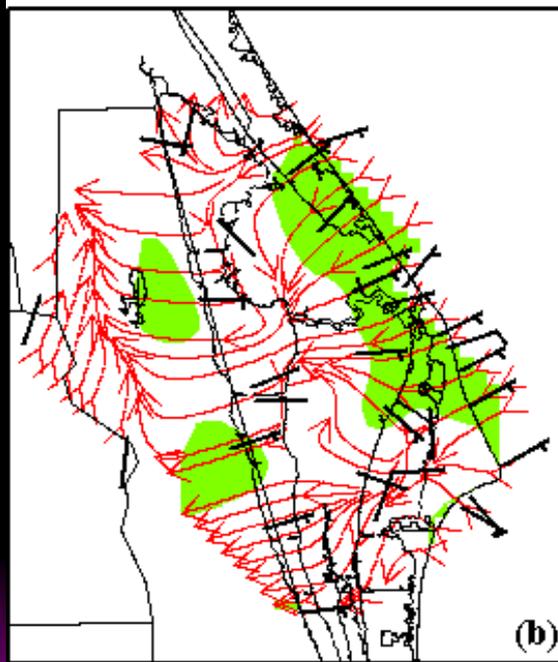
Observed Winds & Sea Breeze Front



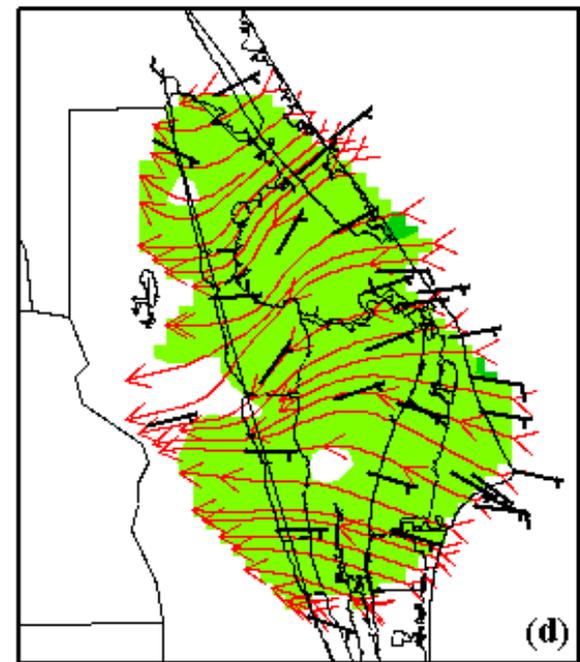
1500 UTC 18 Aug 2000



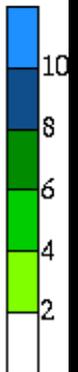
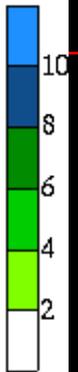
1700 UTC 18 Aug 2000



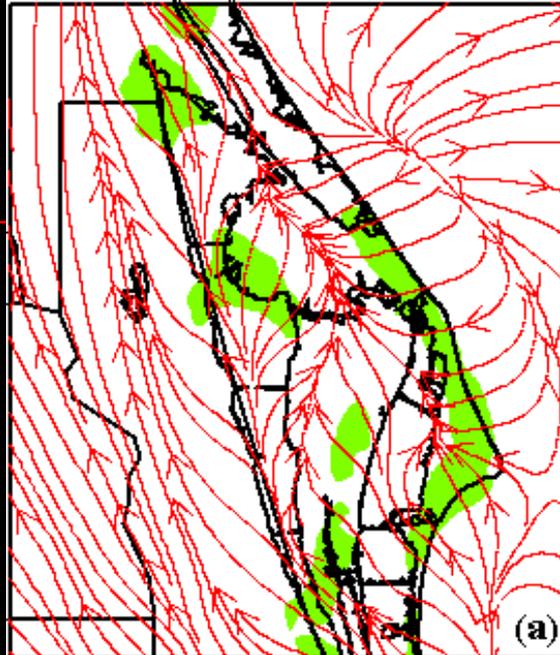
1600 UTC 18 Aug 2000



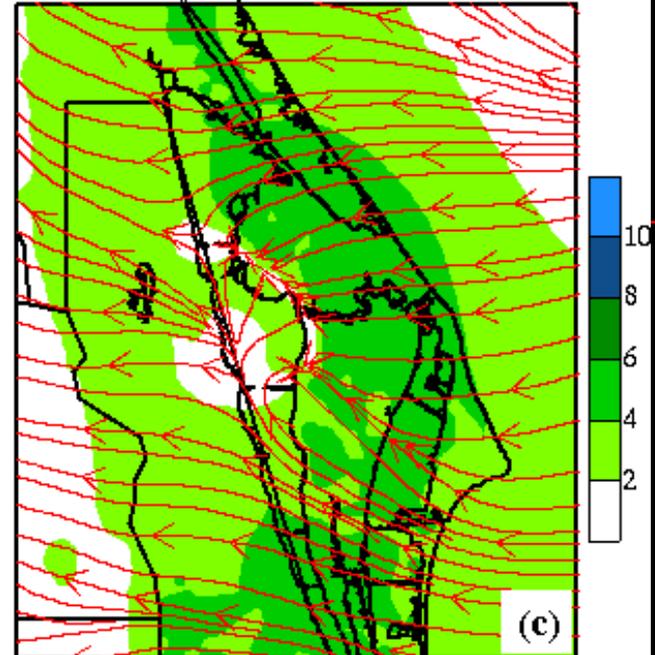
1800 UTC 18 Aug 2000



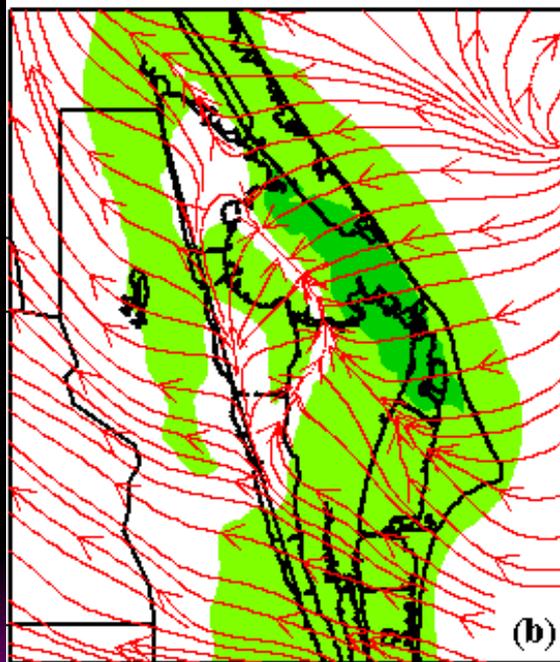
RAMS Forecast Winds & Sea Breeze Front



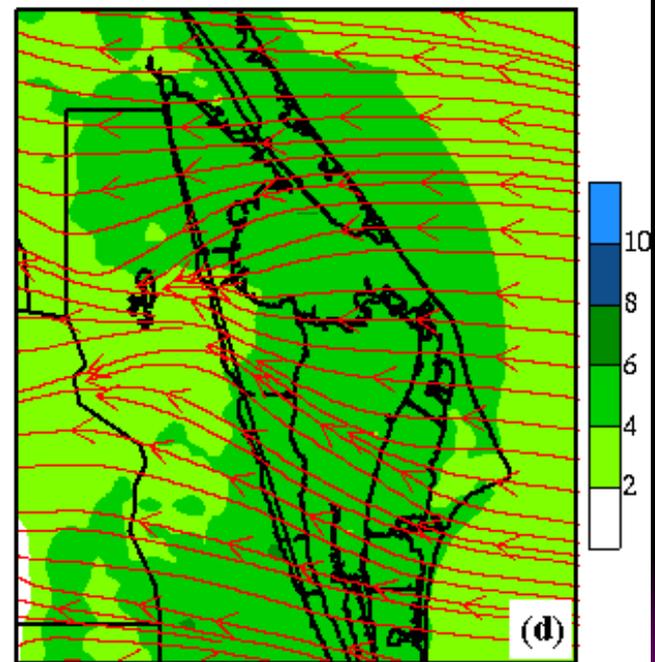
0000 UTC cycle, 18 Aug 2000, 15-h fcst



0000 UTC cycle, 18 Aug 2000, 17-h fcst



0000 UTC cycle, 18 Aug 2000, 16-h fcst



0000 UTC cycle, 18 Aug 2000, 18-h fcst

RAMS Evaluation: Key results

- Surface-based, daytime cool bias of 4.5°C in cool season and 3.5°C in warm season
- Wind direction RMS errors were 40° after 2 hours of run; RMS errors of 60° occurred night and early mornings with light winds
- Thunderstorms caused temperature and wind direction errors due to outflows and cold pools
- Vertical temperature profile too unstable for lowest 0.5 km

RAMS Evaluation: Key results (cont.)

- Finer grid resolution produces better temperature and moisture forecasts
- RAMS underpredicted strength of fronts (winds & temperature)
- RAMS did an excellent job of forecasting onset and movement of sea breeze.
Probability of detection: 0.98
- RAMS predicted first daily thunderstorms within 3 hours of actual initiation 75% of time

Conclusions
